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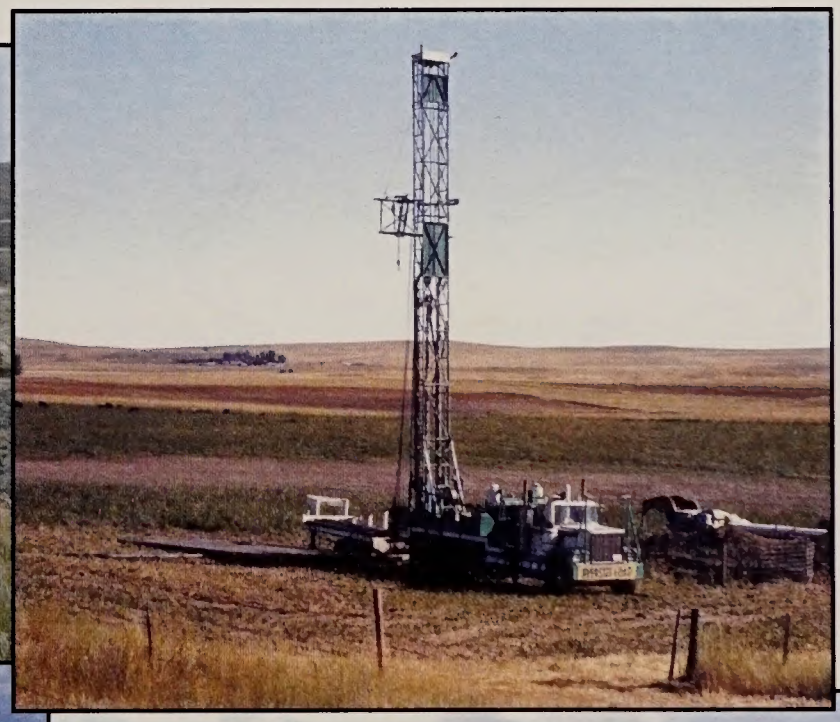
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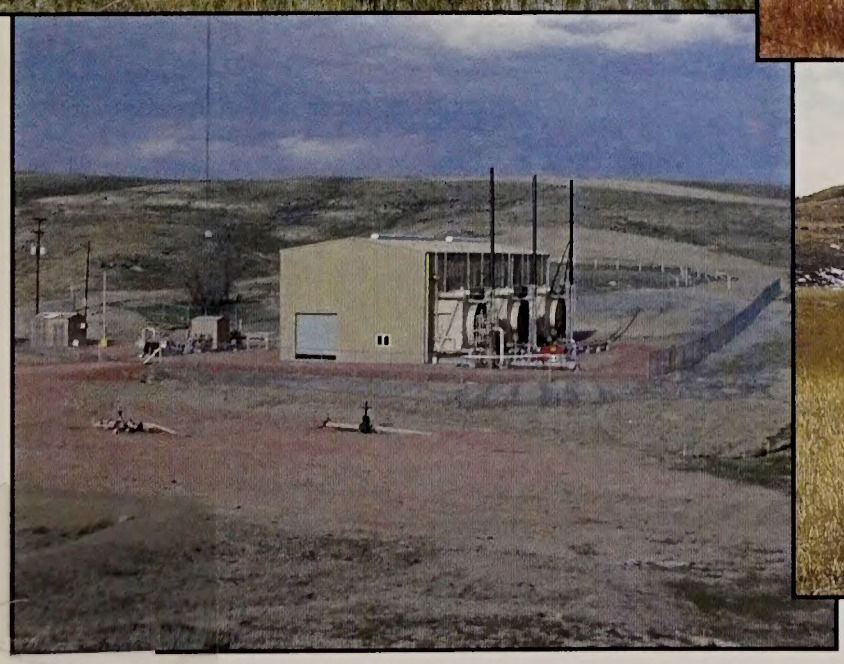
Draft Environmental Impact Statement and Draft Planning Amendment for the Powder River Basin Oil and Gas Project

Volume 1

(WY–070–02–065)









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January 2, 2002

Dear Reader:

The Bureau of Land Management (BLM) has prepared this Draft Environmental Impact Statement (DEIS) to document and disclose the results of environmental analysis. A copy of this document has been provided to you for your review. You also may view the DEIS on the Wyoming BLM homepage (www.wy.blm.gov) and Powder River Basin EIS web site at http://www.prb-eis.org. Copies of the DEIS also are available for public inspection at the following BLM offices:

Bureau of Land Management	Bureau of Land Management	Bureau of Land Management
Wyoming State Office	Buffalo Field Office	Casper Field Office
5353 Yellowstone Road	1425 Fort Street	2987 Prospector Drive
Cheyenne, Wyoming 82009	Buffalo, Wyoming 82834	Casper, Wyoming 82604-2968

We recommend that you begin by reading the Preface of the DEIS, which will orient you to the document.

As a result of the analysis documented in this DEIS, our preferred alternative, at this time, is Alternative 1. We will not; however, make a final decision until we have reviewed comments on the DEIS and completed the FEIS.

Public comments on this DEIS will be accepted for 90 days following the date the Environmental Protection Agency publishes its Notice of Availability in the *Federal Register*. The BLM will notify all parties on the project mailing list of the dates when comments will be accepted. During this time, you are welcome to submit written comments.

During the comment period, the BLM will hold public meetings (anticipated during March 2002) or other public involvement activities. The BLM will notify the public of these meetings or activities through public notices, news media releases, the Wyoming BLM homepage (www.wy.blm.gov), the project's homepage (www.prb-eis.org), or mailings. These notifications will provide at least 15-days' notice of public meetings or gatherings and 30-days' notice of written comment requests.

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The agencies are required to respond in the Final Environmental Impact Statement (FEIS) to all substantive comments submitted on the DEIS. The comment period mentioned above provides you, the public, with an opportunity to make an impact on the content of the document and; therefore, potentially affect the decision that will be made after the FEIS is released. We ask that your comments relate directly to the DEIS, that you are as specific as possible, and that you cite the location or locations in the document on which you are commenting. Although public opinions for or against the alternatives are of interest, often they are not useful for modifying an EIS. Additionally, they seldom have any bearing on the criteria the agencies must use to make decisions regarding proposals. Substantive comments should: (1) give any new information that could alter conclusions; (2) show why or how analysis or assumptions are flawed; (3) show errors in data, sources, or methods; or (4) request assessment clarifications that bear on conclusions.

Please retain this copy of the DEIS for future reference because the FEIS may be published in abbreviated format. If you have any questions or require additional copies of this document, please contact Paul Beels 307-684-1168. We appreciate your interest in the management of the public lands.

Comments on the DEIS should be sent to Paul Beels, Project Manager, Bureau Land management Buffalo Field Office, 1425 Fort Street, Buffalo, Wyoming 82834-2436.

Sincerely,

Alan R. Pierson
State Director

Draft Environmental Impact Statement
Powder River Basin Oil and Gas Project
Campbell, Converse, Johnson, and Sheridan Counties

Lead Agency:

Bureau of Land Management
Buffalo Field Office
Buffalo, Wyoming

Cooperating Agencies:

Bureau of Land Management
Casper Field Office
Casper, Wyoming

USDA Forest Service
Medicine Bow-Routt National Forest
Douglas, Wyoming

State of Wyoming

For Further Information, Contact:

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Abstract

A group of oil and gas companies (Companies) has notified the Bureau of Land Management and Forest Service of their intent to develop additional coal bed methane (CBM) resources in Wyoming's Powder River Basin. The Proposed Action includes drilling, completing, operating, and reclaiming almost 39,400 new CBM wells and constructing, operating, and reclaiming various ancillary facilities needed to support the new wells. The Proposed Action would occur in an almost 8,000,000-acre Project Area. Drilling would begin in 2002 and continue for 10 years.

Three alternatives were considered in detail. They were Alternative 1 — the Proposed Action, Alternative 2 — the Proposed Action with Reduced Emission Levels and Expanded Disposed Water Handling Scenario, and Alternative 3 — No Action. Alternative 1 consisted of a combination of the Companies' proposal and the BLM's Reasonable Foreseeable Development Scenario. Alternative 2 was developed in response to issues raised during the public and agency scoping process. This alternative, which consists of Alternative 2A and 2B, would replace some of the proposed gas-fired compressors with electrical compressors and would involve less water discharged directly to the sub-watersheds. The No Action alternative is required by the National Environmental Policy Act for comparison to other alternatives analyzed in the EIS. For this project, the No Action Alternative would not authorize additional natural gas development on Federal leases within the Project Area. Drilling could continue on State and private leases,

The Wyoming State Director is the BLM's Authorized Officer responsible for preparing this Draft Environmental Impact Statement.

Preface

An Environmental Impact Statement (EIS) usually is not read like a book — from chapter one to the end. The best way to read an EIS depends on your interests. You may be more interested in effects, whereas others might have more interest in the details of the proposed project or be more concerned about what opportunities were made available to the public to be involved in the environmental assessment process. Many readers probably just want to know what is being proposed and how it will affect them.

This document follows the format established in the National Environmental Policy Act's regulations (40 CFR 1500 to 1508). The following paragraphs outline information contained in the chapters and appendices so readers may find the parts of interest without having to read the entire document.

- *Summary*: contains a short, simple discussion to provide the reader and the decision makers with a sketch of the more important aspects of the EIS. The reader can obtain additional, more-detailed information from the actual text of the EIS.

- *Chapter 1 — Purpose and Need*: identifies the proposed action and describes the purpose of and need for the proposed action, history of oil and gas activities in the Powder River Basin, decisions to be made by the agencies, agencies' roles and responsibilities, the National Environmental Policy Act (NEPA) process, and other permits required.

- *Chapter 2 — Public Participation, Issue Identification, and Alternative Development*: describes the Proposed Action, the significant or key issues associated with the Proposed Action, and alternatives to that action, including the no action alternative. Action alternatives that meet the purpose and need were developed by the agencies in response to one or more of the key issues. Alternatives considered but dropped from detailed consideration are identified along with the rationale for not including them in the analysis. This chapter also provides a comparative analysis of the environmental effects of the primary alternatives to provide a clear basis of choice among options for the decision maker and public. The lead agency's preferred alternative is identified.

- *Chapter 3 — Affected Environment*: describes the present condition of the environment that would be affected by implementation of the proposed action or any action alternative.

- *Chapter 4 — Environmental Consequences*: describes the probable direct, indirect, and cumulative effects to the human environment that would result from implementing the Proposed Action or alternatives. The discussion also addresses the short-term uses versus long-term productiv-

ity, unavoidable impacts, and irreversible or irretrievable impacts. Reasonably foreseeable activities near the proposed project are identified.

- *Chapter 5 — Land Use Planning and Management*: contains the analysis of the alternatives for conformance with the Buffalo Resource Area Resource Management Plan, Platte River Resource Management Plan, and Medicine Bow National Forest Land and Resource Management Plan.

- *Chapter 6 — Consultation with Others*: identifies the agencies, companies, and organizations consulted as well as the cooperating agencies.

- *Chapter 7 — Preparers and Contributors*: identifies the people involved in the research, writing, and internal review of the draft EIS.

- *Chapter 8 — Distribution and Review of the Draft EIS*: lists the agencies, organizations, and individuals who received a copy of the draft EIS.

- *Chapter 9 — Glossary*: describes the technical terms used in the draft EIS.

- *Chapter 10 — References Cited*: lists the references cited in the draft EIS.

- *Index*: contains cross references and identifies the pages where key topics can be found.

- *Appendices*: contain technical and non-technical information that is important to full comprehension of the NEPA analysis, but was too long to be included in the primary chapters.

Acronyms and Abbreviations used in this EIS

ADT	Average Daily Traffic
APD	Application for Permit to Drill
AUM	Animal Unit Month
BACT	Best Available Control Technology
bcf	Billion Cubic Feet
BFO	Buffalo Field Office
BFOA	Buffalo Field Office Area
BLM	U.S. Department of Interior, Bureau of Land Management
BMP	Best Management Practices
CBM	Coal Bed Methane
CEQ	Council on Environmental Quality
CFO	Casper Field Office
CFOA	Casper Field Office Area
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CMF	Central Metering Facility
COA	Conditions of Approval
COE	U.S. Army Corps of Engineers
CSU	Controlled Surface Use
CWA	Clean Water Act
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Agency
FLPMA	Federal Land Policy and Management Act
FS	U.S. Department of Agriculture, Forest Service
FWS	U.S. Department of Interior, Fish and Wildlife Service
gpm	Gallons per Minute
HP	Horsepower
kV	Kilovolt
LAD	Land Application Disposal
LRMP	Land and Resource Management Plan
mcf	Thousand Cubic Feet
mmcf	Million Cubic Feet
MMRP	Mitigation, Monitoring, and Reporting Plan
MOC	Memorandum of Cooperation
MW	Megawatt
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NL	No Lease
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOS	Notice of Staking
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource and Conservation Service
NRHP	National Register of Historic Places

NSO	No Surface Occupancy
PM_{10}	Respirable Particulate Matter less than 10 microns in aerodynamic diameter
POD	Plan of Development
ppm	Parts per Million
PRB	Powder River Basin
PSD	Prevention of Significant Deterioration
psi	Pounds per Square Inch
RFD	Reasonably Foreseeable Development
RFFA	Reasonable Foreseeable Future Actions
RMP	Resource Management Plan
ROD	Record of Decision
ROS	Recreational Opportunity Spectrum
ROW	Right-of-Way
SHPO	State Historic Preservation Office
SLT	Standard Lease Terms
SOI	Scenic Integrity Objectives
SUP	Special Use Permit
SUPO	Surface Use Plan of Operations
TBNG	Thunder Basin National Grassland
TCP	Traditional Cultural Properties
TDS	Total Dissolved Solids
TL	Timing Limitation
TSS	Total Suspended Solids
USC	United States Code
USDC	U.S. Department of Commerce
USDI	U.S. Department of the Interior
USDOT	U.S. Department of Transportation
USGS	U.S. Department of Interior, Geological Survey
VQO	Visual Quality Objective
VRM	Visual Resource Management
WDEQ	Wyoming Department of Environmental Quality
WDOT	Wyoming Department of Transportation
WGFD	Wyoming Game and Fish Department
WHMA	Wildlife Habitat Management Area
WOGCC	Wyoming Oil and Gas Conservation Commission
WSEO	Wyoming State Engineer's Office
WSGS	Wyoming State Geological Survey

Summary

A group of oil and gas companies, collectively identified as the Powder River Basin Companies (Companies), has notified the U.S. Department of Interior, Bureau of Land Management (BLM) and U.S. Department of Agriculture, Forest Service (FS) of their intent to develop additional coal bed methane (CBM) resources in Wyoming's Powder River Basin (PRB). Implementation of this project would continue and expand development of CBM that has been occurring in the PRB over the last few years. In general, the Companies propose to:

- Drill, complete, operate, and reclaim almost 39,400 new natural gas wells and
- Construct, operate, and reclaim various ancillary facilities needed to support the new wells, including roads, pipelines for gathering gas and produced water, electrical utilities, and compressors.

The proposed project would occur in an almost 8,000,000-acre Project Area (Figure 1–1 in the EIS). This Project Area encompasses all or parts of Campbell, Converse, Johnson, and Sheridan counties and all or parts of eighteen 4th order watersheds (sub-watersheds). The proposed project would involve both public and privately owned lands. The public lands include lands administered by the BLM, National Forest System lands, and state lands. Additional information on land ownership and jurisdiction is presented in Chapter 3 of the EIS.

Purpose of and Need for the Proposed Action

The Companies hold valid federal, state, and private leases for oil and natural gas in the Project Area. The leases have created contractual and property rights for the Companies from the United States, the State of Wyoming, and private mineral owners to develop oil and natural gas resources. The purpose of the Companies' proposal is to extract, transport, and sell oil and natural gas at a profit from the portions of the Project Area leased by them.

The BLM and FS recognize the extraction of oil and natural gas is essential to meeting the Nation's future needs for energy. As a result, private exploration and development of federal oil and gas reserves are integral parts of the agencies' oil and gas leasing programs under the authority of the Mineral Leasing Act of 1920, as amended by the Federal Land Policy and Management Act (FLPMA) of 1976 and the Federal Onshore Oil and Gas Leasing Reform Act of 1987. The BLM and FS' oil and gas leasing program encourages the development of domestic oil and gas reserves and reduction of the United States' dependence on foreign sources of energy.

As a result of the contractual and property rights created by the valid leases, the direction contained within the BLM's oil and gas leasing program, the status of the BLM's two RMPs and the FS' LRMP and Oil and Gas Leasing Final EIS, the BLM and FS need to evaluate the level of development of oil and natural gas in

the Project Area over the next ten years. Specifically, the BLM and FS need to address the Proposed Action and reasonable alternatives to that action directly, indirectly, and cumulatively.

When the four primary guidance documents identified above were prepared, the levels of development for oil and natural gas anticipated at the time were less than levels currently proposed by the Companies and the agencies' current Reasonably Foreseeable Development (RFD) Scenario (Appendix A). In particular, the current and proposed levels of development of CBM were not specifically defined. Consequently, the BLM and FS need to evaluate conformance of the Proposed Action and alternatives to that action with the Buffalo RMP, Casper RMP, Medicine Bow National Forest's LRMP, and the TBNG Oil and Gas Leasing EIS and, if necessary, amend these documents to address the additional development comprising the selected alternative.

Therefore, this EIS serves five purposes. First, it provides the basis to analyze and disclose the impacts of the level of development proposed within the Project Area (both under the Proposed Action and RFD scenario). It addresses the effects of implementing a level of development of oil and natural gas within the Project Area that is conceptual in nature. The wells, roads, pipelines, and ancillary facilities depicted in this EIS represent a proposed level of development and tentative locations for these facilities. The final location for each component would be determined through future site-specific analyses that the BLM and FS would require for each facility. These analyses would occur when the Companies file applications for each component, such as an Application for Permit to Drill (APD), a FS Special Use Permit (SUP), or a BLM Right-of-Way (ROW) Grant.

Second, this EIS provides the means for the BLM and FS to provide federal minerals to meet the Nation's energy needs. It also facilitates protection of the financial interest of the United States by preventing the drainage of federal minerals.

Third, the EIS identifies mitigation measures to address issues and conditions of approval for the subsequent site-specific applications for individual locations. These measures and conditions would be incorporated into the process during permitting of the individual facilities (again through the APD, SUP, or ROW Grant processes).

Fourth, the FS will use the analysis documented in this EIS to revise the 1994 leasing decisions on those portions of the TBNG that have potential for CBM development (about 80,000 acres of National Forest System lands). The outcome of the impact analysis will be assessed against current lease stipulations to determine whether the current LRMP lease stipulations need to be modified or if new stipulations need to be developed. This decision would revise previous decisions made by the FS for the TBNG.

Finally, similar to the FS, the BLM is also using the outcome of the impact analysis to review the existing RMP decisions. This includes areas open and closed to leasing, lease stipulations, and authorized mitigation measures. This review will determine whether: (1) changes to current designations of areas open and closed to oil and gas leasing need to be made, (2) current RMP lease stipulations need to be modified or new stipulations need to be developed, and (3) new

mitigation measures need to be enacted. Should items one, or two, or both be determined to be necessary for either of the two RMPs, an amendment would be needed. If the decision maker determines the BLM needs to amend one or both RMPs, the analyses contained in this EIS will provide the basis for amending the RMPs. The Final EIS and ROD would serve as amendments to the Buffalo RMP and Casper RMP.

NEPA Process, Including Tiering and Decision Making

The National Environmental Policy Act (NEPA) and directives by the Council on Environmental Quality (CEQ) require the BLM and FS to analyze proposed actions involving federal lands and leases in terms of their potential effects on the human environment. Furthermore, regulations implementing the Mineral Leasing Act of 1920 require the BLM and FS to review and act on APDs and attached Surface Use Plans of Operations (SUPO) and to decide on the requirements for surface occupancy provided by the SUPO. The BLM and FS also issue ROW Grants and SUPs, respectively, to construct and operation linear transportation facilities, such as roads and pipelines, across federal lands under Title V of FLPMA and the Mineral Leasing Act.

The analysis of effects to the human environment discloses the potential environmental consequences of proposed actions and alternative actions. Another responsibility of the BLM and FS is establishing provisions for ensuring the reclamation of facilities and disturbed lands if an oil and gas operator would fail to complete adequate reclamation efforts. Bonds are required for oil and gas operations on federal leases to indemnify the government for safe rehabilitation, royalty payments, and civil penalties. Bonds also are required for ROWs on federal lands.

The BLM, Buffalo Field Office in Buffalo, Wyoming is the lead federal agency responsible for conducting the NEPA analysis and preparing this EIS. The FS (Medicine Bow National Forest) is a cooperating agency and is responsible for protecting non-mineral resources on National Forest System lands in the TBNG. The development of the Proposed Action and the alternatives was conducted by an oversight team consisting of the BLM, FS, State of Wyoming agencies, five conservation districts, and the four counties. Wyoming agencies specifically designated to represent the State as a cooperating agency on this team included the Office of Federal Land Policy, Department of Environmental Quality (WDEQ), the Wyoming Oil and Gas Conservation Commission (WOGCC), and Wyoming State Engineer (WSEO). The State also designated another eight agencies to assist these four agencies.

This document provides the responsible agencies with information upon which to base a final decision that considers factors relevant to the proposal. Scoping issues and concerns raised by the public and agencies drove the development of alternatives and focused the environmental impact analysis. This EIS documents (1) the analysis of effects that could result from implementation of the Proposed Action or alternatives and (2) the development of environmental protection measures necessary to reduce or eliminate environmental consequences.

The regulations implementing NEPA encourage tiering in EISs. Tiering is the process of referencing information presented in other previously prepared NEPA documents, such as EISs to minimize repetition. This EIS is specifically tiered to the four guidance documents identified previously.

Finally, this EIS is not a decision document; it documents the process used to analyze the potential environmental consequences of implementing the proposed oil and gas development project and alternatives to the Proposed Action. The decisions about the proposed project will be documented in separate RODs (one for the BLM and one for the FS) signed by the agency's responsible official. The BLM and FS' decisions will apply to federal lands and leases administered by both agencies. Decisions by other jurisdictions to issue or not to issue approvals related to this proposal may be aided by the disclosure of effects available in this analysis.

Decisions to be Made Based on this NEPA Analysis

The decision makers for the BLM (Wyoming State Director) and FS (Medicine Bow-Routt National Forests Supervisor) will decide based on the analysis documented in this EIS, whether current RMP or LRMP lease stipulations are adequate or if new stipulations need to be developed. They will determine whether any changes to current designations of areas open or closed to oil and gas leasing need to occur. Also, they will determine if new mitigation measures need to be adopted, and if any of the management plans need to be amended.

Decisions to be Made Following this NEPA Process

The RODs associated with this EIS will not be the final review or the final approvals for all actions associated with the PRB Oil and Gas Project. Although the RODs would approve a maximum level of oil and gas development and its general location, the BLM and FS must analyze and approve each component of the project that involves the disturbance of federal lands on a site-specific basis. The method used to evaluate each surface-disturbing activity is the APD or ROW Grant/SUP, which would be required before any construction can occur.

The APD includes a surface use program and a drilling plan. The detailed information to be submitted under each program is identified in Onshore Oil and Gas Order No. 1 and 43 Code of Federal Regulations (CFR) 3162.3. An on-site inspection of the locations proposed for the well, access road, pipelines, and other areas of proposed surface use would be conducted before approval. The inspection team would include the BLM, FS (if construction would occur on National Forest System lands), the lessee or its designated representative, the primary drilling and construction contractors, and federal grazing lessees. For inspections involving split estate lands (lands with private surface ownership and federal minerals ownership), the BLM also would invite the surface owner to attend.

The purpose of the on-site inspection would be to identify potentially sensitive areas and the environmental consequences associated with the proposal at each specific location and site-specifically apply the methods needed to mitigate those effects. The on-site could include site-specific surveys for cultural resources or threatened or endangered species, if the potential for occurrence of these resources exists on or near the proposed disturbance. After the site inspection, the APD may be revised or site-specific mitigation may be added as Conditions of Approval to the APD, consistent with applicable lease terms, for the protection of surface or subsurface resource values near the proposed activity. These may include adjusting the proposed locations of well sites, roads, and pipelines; identifying the construction methods to be employed; and identifying reclamation standards for the lands.

Since the issuance of the ROD for the Wyodak Final EIS, the BLM has been requiring that CBM projects be submitted as Plans of Development (POD). A POD is a group of wells and their supporting infrastructure (e.g., roads, pipelines, power lines, water discharge points, booster stations, and compressor stations) for a given geographic area or sub-watershed. The POD helps the operators develop a logical, economical, environmentally sound CBM project that the BLM can efficiently process and approve.

The BLM is responsible for conducting an environmental analysis on BLM lands (BLM surface ownership and all federal minerals ownership), preparing the documentation, and providing mitigation measures to protect surface resources for APD approval. The FS would have similar responsibilities on National Forest System lands. The BLM is responsible for approval of the drilling program, protection of ground water and other subsurface resources, and final approval of the APD on both BLM and National Forest System lands.

Access roads and pipelines on BLM-managed land outside the applicant's lease would require a ROW Grant. Likewise, facilities on National Forest System lands would require an SUP. The APD could be acceptable as an application for a ROW Grant or SUP for off-lease facilities, if it provides sufficient detail of the entire proposal.

After drilling, routine well operations would not require approval. However, the BLM would have authority for approving a variety of related activities. Any changes to an approved APD, certain subsequent well operations, and all subsequent new surface disturbances, such as workover pits, would require prior approval. Complete details of subsequent well operations are contained in 43 CFR 3162.3–2. Disposal of produced water from Federal leases would require prior approval, as outlined in Onshore Oil and Gas Order No. 7. The BLM also would approve plugging and abandonment of wells, hydrogen sulfide protection measures (if necessary), gas venting, gas flaring, and certain measures for handling production.

Public Participation

The BLM and FS consider public participation a crucial component in defining the scope of the environmental analysis presented in this EIS. Consequently, the agencies worked to ensure the public was informed about the Companies' pro-

posal and the opportunities available for participating in the environmental process.

The agencies first informed the public of the BLM and FS' intent to conduct an environmental impact analysis of oil and gas development within the PRB during May and June 2000. In May, the agencies prepared and mailed almost 900 copies of a Scoping Letter, which solicited comments from its readers to assist the BLM and FS in identifying the specific issues and concerns the agencies should address in the analysis and document in the EIS.

On 21 June 2000, formal scoping for the analysis began with publication in the Federal Register of a Notice of Intent (NOI) to prepare an EIS. The BLM published additional notices in the Federal Register to correct mistakes in the first NOI and to invite the public's participation in the analysis and potential amendments to the Buffalo and Platte River Resource Management Plans.

The BLM also sent a news release to more than 60 media outlets (e.g., newspapers, radio stations, and television stations) in Wyoming and Montana. This news release announced the agencies' intention to prepare an EIS and identified the public meetings. Additionally, several newspapers prepared stories on the project.

In addition to the publications and mailings, the agencies held four public meetings to discuss the proposal and receive comments from the public. The first meeting was held in Sheridan, Wyoming on 6 June 2000. The second and third meetings were held in Buffalo, Wyoming and Gillette, Wyoming on 7 and 8 June 2000, respectively. The final meeting was held in Douglas, Wyoming on 12 June 2000. At all meetings, the proposal was described and attendees were provided the opportunity to ask questions and submit comments.

Finally, the BLM and FS have been keeping the public informed of the analysis' status through a periodic newsletter and project-specific web site (www.prb-eis.org). The BLM also placed project information on its Wyoming web site.

Issue Identification and Issue Statements

The BLM and FS reviewed and analyzed the comments they received during the scoping process. Public response to the notices and meetings included 74 letters, comment forms, and e-mails. Also, a total of 106 people attended one or more of the four public meetings.

The agencies' process for identifying issues involved three overall steps. First, specific comments were arranged into groups of common concerns. Next, a primary issue statement was prepared for each group of comments. Finally, the issue statements were evaluated for applicability to this NEPA analysis.

The analysis of comments initially identified 27 issues. Eighteen of these 27 issues were identified as key or significant issues (see November 2000 Scoping Summary to review nonsignificant issues). These issues were used to define the scope of this NEPA analysis. These key issues were used to analyze environmental effects, prescribe mitigation measures, or both. Issues are "significant or

key" due to the extent of their geographic distribution, the duration of their effects, or the intensity of interest or resource conflict. The determination of an issue's significance is different than and separate from any determination of the significance of an environmental consequence. The other nine issues were not identified as key because they involved standard parts of a NEPA analysis (e.g., the analysis must consider an adequate range of alternatives) or the agencies determined they were beyond the scope of this NEPA analysis. The 18 key issues that comprised the overall scope of the NEPA analysis are:

Issue 1: *The effects of the additional development of oil and gas resources on aquifers present in and down gradient of the project area.*

Issue 2: *The effects of the additional development of oil and gas resources on the quantity and distribution of surface water in and downstream of the project area.*

Issue 3: *The effects of the additional development of oil and gas resources on the quality of surface water in and downstream of the project area and the potential to adversely affect current uses of those surface waters.*

Issue 4: *The effects of the additional development of oil and gas resources on the project area's geology, geologic hazards, and the extraction of other mineral resources present in the project area.*

Issue 5: *The effects of the additional development of oil and gas resources on soils in and downstream of the project area.*

Issue 6: *The effects of the additional development of oil and gas resources on air quality and visibility.*

Issue 7: *The effects of the additional development of oil and gas resources on vegetation in and downstream of the project area, including wetlands and riparian areas.*

Issue 8: *The effects of the additional development of oil and gas resources on species of wildlife and their habitats (particularly key species and habitats).*

Issue 9: *The effects of the additional development of oil and gas resources on fisheries and aquatic habitats.*

Issue 10: *The effects of the additional development of oil and gas resources on the project area's ecological integrity and biological diversity.*

Issue 11: *The effects of the additional development of oil and gas resources on special-concern species, particularly threatened, endangered, candidate, or sensitive species of plants and animals.*

Issue 12: *The effects of the additional development of oil and gas resources on rangeland resources and grazing operations.*

Issue 13: *The effects of the additional development of oil and gas resources on cultural resources, paleontological resources, and Native Americans.*

Issue 14: *The effects of the additional development of oil and gas resources on recreational opportunities and the recreational experience.*

Issue 15: *The effects of the additional development of oil and gas resources on the project area's aesthetics.*

Issue 16: *The effects of the additional development of oil and gas resources on the local economy.*

Issue 17: The effects of the additional development of oil and gas resources on human health and safety.

Issue 18: The analysis needs to include an analysis of environmental justice.

Alternatives Analyzed in Detail

Three alternatives were analyzed in detail: (1) Proposed Action, (2) Proposed Action with Reduced Emission Levels and Expanded Produced Water Handling Scenarios, and (3) No Action.

Alternative 1 – The companies' proposed action was combined with the BLM's Reasonable Foreseeable Development (RFD) Scenario. The RFD Scenario is based primarily on geology (potential for oil and gas resource occurrence) and past and present oil and gas activity, with consideration of other significant factors such as economics, technology, and physical limitations on access, existing or anticipated infrastructure and transportation.

Along with industry's proposed action, which relates only to coal bed methane activity, the BLM's RFD forecasts the continued drilling of an estimated 3,200 oil wells. The RFD also forecasts there could be an estimated 51,000 CBM wells in the EIS area over the next ten years.

The companies' projections of CBM well drilling and production include various ancillary facilities within the Project Area. The ancillary facilities include access roads, pipelines for gathering gas and produced water, electrical utilities, facilities for treating and compressing gas and disposing of produced water, and pipelines for delivering gas under high pressure to transmission pipelines. Although the Companies would develop new wells throughout the 10-year period beginning in 2002, most of the drilling would occur during the first eight years. All 51,000 wells would not be drilled into a single coal seam. Wells drilled into different coal seams can be collocated on common well pads. The projected number of well pads is 35,589. The total numbers of wells and well pads is based on an 80-acre well spacing pattern (eight pads per square mile). The 51,000 proposed CBM wells include an estimated 12,000 existing wells.

Under the Proposed Action, the Companies would construct, operate, and maintain wells and ancillary facilities in 10 of the 18 sub-watersheds that comprise the Project Area. However, most of the new wells (63 percent) and facilities would be constructed in two sub-watersheds: the Upper Powder River and Upper Belle Fourche River sub-watersheds. Sub-watersheds with relatively high numbers of wells and facilities include Clear Creek, Crazy Woman Creek, Tongue River, and Little Powder River.

Overall, implementation of the Proposed Action could disturb as many as 212,000 acres. This short-term disturbance would encompass about 3 percent of the Project Area. Most of this would be associated with the construction of pipelines and roads. Long term disturbance is projected to be approximately 109,000 acres. Compressor stations would account for the smallest amount of the overall disturbance.

Construction of the Powder River Basin wells would begin during 2002. Generally, construction of most CBM wells would be completed over the first eight years (by the end of 2010). The production lifetime of the wells is expected to be about 7 years and final reclamation is expected to be completed during the two to three years following the end of production.

Emphasis for water handling for Alternative 1 is untreated surface discharge. All compression would be CBM powered.

Alternative 2 proposes the same number of CBM and conventional wells as the proposed action. There are two additional water-handling methods analyzed: A – Emphasis on infiltration and B – emphasis on treatment for beneficial use.

There are also two air quality options: A- Fifty percent of the booster compression would be electrically powered and B – One hundred percent of the booster compression would be electrically powered.

Alternative 3 – No Action This alternative would consist of no new federal wells. Wells would only be developed on state and private mineral ownership.

Affected Environment

The PRB is part of the Missouri Plateau of the Great Plains. This region is characterized by rolling uplands that have been greatly dissected by tributaries of the Missouri River system. The Bighorn Mountains, which are part of the Rocky Mountains, lie just west of the PRB, partially within the westernmost portion of the Project Area. On the east, the PRB is bounded by the Black Hills. On the south, the PRB is bounded by the Casper arch, the Laramie Mountains, and the Hartville Uplift.

The PRB consists of a dissected, rolling upland plain, with low to moderate relief, broken by buttes, mesas, hills, and ridges. Extensive areas of open high hills in the northern portion of the Project Area indicate rough, broken terrain where moderate to deep erosion has occurred. Erosion-resistant clinker, produced by the natural burning of coal beds in the PRB, caps many hills and ridges within the Project Area with a characteristic broken, red brick or scoria-like rock. Elevations in the Project Area range from 3,350 to 9,250 feet above msl.

The PRB is drained toward the north and east by the Tongue, Powder, Little Powder, Belle Fourche, and Cheyenne Rivers, which all flow into the Missouri River system. The Project Area forms a low divide among these smaller drainage systems. The major river valleys have wide flat floors and broad floodplains. Tributaries in the Project Area are incised and drain areas of isolated, flat-topped, clinker-covered buttes and mesas, 100 to 500 feet above the valley floor. Flow in the Project Area is generally towards the northeast. Perennial streams generally originate in the mountainous areas because of significant annual precipitation and geologic conditions that foster groundwater discharge.

Surface water quality in the Project Area is generally adequate to support designated uses. Surface waters in the Project Area are typically alkaline, with moderate to high levels of hardness. These waters vary from a calcium bicarbonate type

water in the mountain streams, to a sodium sulfate type water in the lowlands. Surface water quality in the Project Area is affected by depletions and return flows from irrigation. Surface water withdrawals in the Project Area are used to support agricultural, domestic, and stock water uses. Irrigation use accounts for about 98 percent of the surface water withdrawals in the Project Area.

The groundwater resources of the PRB that are at or near the land surface within the PRB are contained in unconsolidated Quaternary alluvial or basin fill deposits or in semi-consolidated to consolidated lower Tertiary sandstones and coal beds that are the uppermost aquifers in the Northern Great Plains aquifer system. Clinker, which is also an aquifer, has formed from some of the lower Tertiary sediments. The Lower Tertiary Aquifer System consists of the Wasatch aquifers, the Fort Union aquifers contained in the Tongue River member of the Fort Union Formation, the Lebo confining layer, and the Tullock aquifer.

The PRB contains some of the largest accumulations of low sulfur sub-bituminous coal in the world. Thick coal deposits occur at or near the surface along the eastern boundary of the Project Area, along a north-south trend situated west of both Gillette and Wright, and in the northwestern portion of the Project Area. Important coal seams within the Wasatch Formation, from oldest to youngest, include the School, Badger, Felix, and Lake De Smet coals. Important coal seams within the Fort Union Formation, from oldest to youngest, include the Canyon, Anderson, Wyodak, and Big George coals. About 25 trillion cubic feet (tcf) of CBM may be recoverable from coal beds in the PRB within Wyoming.

Although specific air quality monitoring is not conducted throughout most of the Project Area, air quality conditions in rural areas are likely to be very good, as characterized by limited air pollution emission sources (few industrial facilities and residential emissions in the relatively small communities and isolated ranches) and good atmospheric dispersion conditions, resulting in relatively low air pollutant concentrations. Occasional high concentrations of carbon monoxide (CO) and particulate matter may occur in more urbanized areas (e.g. Buffalo, Gillette, and Sheridan) and around industrial facilities, especially under stable atmospheric conditions common during winter.

The Project Area is characterized as a mosaic of vegetation types that includes prairie grasslands, shrublands, riparian areas, and forested areas. Fourteen vegetation types were identified within the Project Area. They are short-grass prairie, mixed-grass prairie, wet meadow, herbaceous riparian, sagebrush shrubland, other shrubland, shrubby riparian, coniferous forest, aspen, forested riparian, agriculture, urban/disturbed, barren, and water. These broad categories often represent several vegetation types that were similar in terms of dominant species and ecological importance.

All of the vegetation types present in the Project Area provide habitats for some wildlife species. In an undisturbed condition, the major vegetation types in the Project Area provide high-quality habitats for many wildlife species. Because these habitats tend to occur in a mosaic across the landscape, many wildlife species can be expected to use more than one habitat. Primary species of wildlife of concern in the Project Area include the pronghorn antelope, mule deer, white-tailed deer, elk, moose, sage grouse, sharp-tailed grouse, and various raptors.

Perennial streams in the Project Arca support a diverse fish fauna of mostly native, game and nongame species.

Not surprisingly, the Project Area supports a variety of special-status species about which management agencies are concerned. These species of plants and animals include those listed by the U.S. Department of Interior, Fish and Wildlife Service (USFWS) as threatened or endangered or being considered for listing as threatened or endangered. They also include species that the BLM or FS consider rare or sensitive.

A variety of prehistoric and historic cultural resource sites that have been documented in each of the sub-watersheds in the Project Area by site type or historic theme, and by National Register evaluation. The files search for this area contains a high proportion of sites that are unevaluated or for which information on evaluation is lacking – 35.6 percent for prehistoric and 35 percent for historic. The files search tables show 13 percent of the prehistoric sites and 9.6 percent of the historic sites as listed or eligible. Typically, when adequate information is available, about 10 to 15 percent of the documented sites in an area are evaluated as eligible for listing in the National Register of Historic Places.

Land ownership in the Project Area consists primarily of private lands intermingled with federal and state lands. Mineral ownership in the Project Area consists primarily of federal mineral estates. Rangeland/livestock grazing is the dominant land use for both public and private lands in the Project Area.

Gillette and Sheridan are the hubs for the transportation network in the Project Area. Interstate highways in the Project Area include I- 25 and I-90. The major north-south transportation corridors include State Route 59 in Campbell and Gillette Counties, and I-25 in Johnson and Sheridan Counties. The principal east-west highway for Campbell and Johnson Counties is I-90. I-90 runs north from the Town of Buffalo to the City of Sheridan, and then continues north to the Montana State line. U.S. Highways in the Project Area include U.S. Routes 14, 16 to the East of Buffalo, and 87. The Primary State Highways in the Project Area are Routes 59, and 387. Secondary State Highways traversing the area include Routes 50, 51, 192, 196, 338, and 450. Numerous county roads also provide local access to public and private lands within the Project Area.

Oil and gas pumping units and associated well pads and access roads are evident throughout the Project Area. However, most of the existing well development is in the eastern half of the Project Area. Well development is most evident in Campbell County between the cities of Gillette and Wright, and north, west, and northwest of Gillette. Development is also evident along Interstate 90 and State Highway 14 and 93 in Campbell and Sheridan Counties. The landscape that has resulted from ongoing oil and gas development in this area is rural/industrial in character.

Most of the areas with significant scenic values occur in the western part of the Project Area. The South Big Horns Area is located in the southwest quarter of Johnson County, primarily within the Middle Fork Powder River sub-watershed. The area provides sensitive and unique resource values, including scenery. Special management areas within the South Big Horns Area include the Middle Fork

Recreation Area, the Red Wall/Hole-in-the-Wall area, Outlaw Cave, Dull Knife Battlefield site, and the Gardner Mountain and North Fork Wilderness Study Areas. The Powder River breaks in eastern Johnson County, the Fortification Creek SMA and WSA, and the Weston Hills Recreation Area in the eastern part of the Project Area also provide scenic settings for a variety of dispersed recreational activities.

Two scenic byways exist in the western part of the Project Area. They provide access to the Bighorn Mountains. The Bighorn Scenic Byway is on U.S. Route 14 west of Ranchester. The Cloud Peak Skyway is on U.S Route 16 west of Buffalo.

Recreational use of the Project Area is limited because more than 75 percent of the land is privately owned. Opportunities for dispersed recreation exist on federal and state lands throughout the Project Area. A few developed recreational sites or facilities exist within special management areas on federal lands in the Project Area. Developed recreational facilities, such as campgrounds, are generally limited to private lands in or near to larger communities in the Project Area, and to state historical sites located in the western part of the Project Area. Communities in the Project Area, including Sheridan, Gillette, Wright, Buffalo, and Kaycee, provide a variety of municipal and private recreational facilities, including golf courses, rodeo grounds, ball parks, and swimming pools.

Major sources of noise are towns; industrial facilities; major roadways, such as Interstate 90; railroad corridors; and frequent high winds. Noise in rural areas away from industrial facilities and transportation corridors is generally 30 to 40 dBA when the winds speeds are low. Levels of noise close to industrial facilities and transportation corridors are likely to be in the range of 50 to 70 dBA depending on the proximity to these sources. The most significant noise from CBM operations results from the operation of compressor stations that use multiple engines to move natural gas from central gathering facilities and along high-pressure transmission pipelines. Noise from these compressor stations has been estimated has been estimated to be 55 dBA at 600 feet from the compressor station.

The Project Area encompasses all or portions of Converse, Campbell, Johnson, and Sheridan counties in Wyoming. It also includes four incorporated municipalities: Gillette, Wright, Sheridan, and Buffalo. Gillette is the county seat and the largest incorporated city in Campbell County. Wright is in southern Campbell County. Sheridan is the county seat of Sheridan County and Buffalo is the county seat of Johnson County.

Summary Comparison of Alternatives and Environmental Consequences

The following tables summarize the alternatives considered in detail and the likely environmental consequences of each alternative. S–1 contains the summary of alternatives. This table contrasts the four alternatives in terms of their physical characteristics. The matrix presented in S–2 provides a comparison summary of the effects to the various environmental resources that would be real-

ized by implementing each of the four alternatives for the Powder River Basin Oil and Gas Project.

Agency-Preferred Alternative

The BLM's preferred alternative is Alternative 1 — Proposed Action. This alternative provides for the best balance of effects to costs and development of the CBM. Most of the federal minerals in the Project Area have already been leased. The pattern of federal and non-federal mineral ownership coupled with the BLM's responsibilities under 43 CFR 3162.2 to prevent drainage of federal oil and gas preclude the BLM from choosing Alternative 3 as the preferred alternative.

Alternatives 2A and 2B offer some advantages over Alternative 1; however, the advantages are insufficient to justify the additional costs and disturbance. Both alternatives 2A and 2B would increase short- and long-term disturbance over Alternative 1 by at least 10 percent. However, as documented in the analysis they would not substantially decrease effects to air quality, visibility, and water quality — the primary issues for which the alternatives were developed. The amount of CBM water produced by alternatives 1, 2A, and 2B would be the same. The costs of implementing the water handling procedures of alternatives 2A and 2B would be substantially higher than those associated with Alternative 1, but the difference between the effects of these two alternatives and Alternative 1 does not reflect or justify these additional costs. The analysis documents that the benefits to air quality and visibility from electrifying half or all of the booster compressors would be insufficient to justify the additional costs of requiring the Companies to use electric booster compressors. It is estimated that few booster compressors would be built on surface that is federally owned and BLM does not have the ability to require electrification of compressors constructed off of federal surface. The permitting of the compressors is the responsibility of the State of Wyoming.

Proposed RMP/LRMP Amendments

The FS is using the analysis documented in this EIS to make a decision on authorization of leases on those portions of the TBNG that have potential for CBM development. The FS has released a Final EIS and Proposed LRMP for the TBNG. In that analysis, they deferred the lease authorization decision for this analysis. The lease availability decision will be made in the ROD for the LRMP EIS.

The outcome of the impact analysis has shown no need for changes to areas open and closed to oil and gas leasing or stipulations proposed in the Final LRMP EIS. Several new mitigation measures would be required for lease authorization.

The BLM has also reviewed the existing RMP's against the NEPA impact analysis. Proposed for the Buffalo RMP:

- No changes to current designations of areas open or closed to leasing.
- No changes to current, or addition of any new, lease stipulations.

- No changes to current resource objectives or decisions.
- Several new mitigation measures would be implemented.

The proposed RMP amendment would include this impact analysis of the new RFD for oil and gas.

Proposed for the Platte River RMP:

- No changes to current designations of areas open or closed to leasing.
- No changes to current, or addition of any new, lease stipulations.
- No changes to current resource objectives or decisions.
- Several new mitigation measures would be implemented.

The proposed RMP amendment would include this impact analysis for the Converse County portion of the Project Area.

The Final EIS and ROD would serve an amendment to the Buffalo RMP. The FS would need a ROD for their authorization decision.

Table S–2 Summary Comparison of Alternatives Considered in Detail

Parameter	Alternative 1	2A	2B	3
New CBM Facilities				
Number of Wells				
Federal ownership	23,909	23,909	23,909	0
Non-federal ownership	15,458	15,458	15,458	15,458
Total	39,367	39,367	39,367	15,458
Number of Well Pads				
Federal ownership	15,455	15,455	15,455	0
Non-federal ownership	10,542	10,542	10,542	10,542
Total	25,997	25,997	25,997	10,542
Roads (miles)				
Improved	6,657	6,657	6,657	2,170
Two-track	10,619	10,619	10,619	4,337
Pipeline (miles)				
2–3-inch poly	14,127	14,127	14,127	5,769
12-inch poly	5,311	5,311	5,311	2,170
12-inch steel	1,036	1,036	1,036	396
Overhead Electric Line (miles)	5,311	5,311	5,311	3,170
Compressors				
Number of booster units	1,060	1,060	1,060	350
Number of booster stations	186	186	186	175
Total horsepower of booster units	371,000	371,000	371,000	122,500
Number of reciprocating units	298	298	298	97
Number of reciprocating stations	63	63	63	19
Total horsepower of reciprocating units	491,700	491,700	491,700	160,050
Water Handling Facilities				
Analyzed number of surface discharge facilities	1,216	498	795	419
Analyzed number of infiltration facilities	1,821	4,032	2,931	893
Analyzed number of containment impoundments	37	43	36	16
Analyzed number of injection wells	285	342	342	147
Projected Short-term Disturbance (acres)	211,992	230,886	222,860	90,807
Projected Long-term Disturbance (acres)	108,799	127,693	119,667	45,057
Workforce Requirements				
Construction and installation (number of workdays)	2,403,944	2,805,164	2,594,436	803,769
Operation and maintenance (number of workdays)	1,814,275	1,815,831	1,815,020	704,814
Reclamation and abandonment (number of workdays)	1,427,421	1,713,259	1,568,892	405,719
New non-CBM Facilities				
Number of new wells				
Federal ownership	1,791	1,791	1,791	0
Non-federal ownership	1,409	1,409	1,409	1,409
Total	3,200	3,200	3,200	1,409
Projected short-term disturbance (acres)	17,599	17,599	17,599	7,751
Projected long-term disturbance (acres)	14,402	14,402	14,402	6,339
Workforce Requirements				
Construction and installation (number of workdays)	96,800	96,800	96,800	43,712
Operation and maintenance (number of workdays)	73,600	73,600	73,600	29,275
Reclamation and abandonment (number of workdays)	19,200	19,200	19,200	8,070

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Groundwater				
Maximum Drawdown				
Fort Union Formation	300–1,200 feet	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Deep Wasatch Sands	10–250 feet	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Shallow Wasatch Sands	1–50 feet (in areas of thin Wasatch cover)	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	-1 to –50 feet (below impoundments and creeks receiving CBM discharge)	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Period of Maximum Drawdown				
Fort Union Formation	2006–2009	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Deep Wasatch Sands	2009–2018	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Shallow Wasatch Sands	2006–2012 (drawdown areas) 2006–2009 (buildup areas)	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Recharge	Recharge of shallow Wasatch increased during CBM development due to infiltration below creeks and impoundments receiving CBM discharge water.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Quality	Groundwater quality within the regional aquifer systems and alluvial aquifers would not be noticeably affected.	Same as Alternative 1	Same as Alternative 1.	Same as Alternative 1
Recovery	Rapid initial recovery of water levels in developed coals following cessation of CBM pumping. Typically >80% recovery within first 10 years. Recovery to within 20 to 50 feet of pre-development water levels occurs over 50 to 100 years. Similar pattern for deep Wasatch Sands but lagged by about 10 years.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	2A	2B	3
Springs/Wells	Wells completed in developed coals within 10 miles of CBM development are likely to experience water level drops and possibly methane occurance. Flowing artesian wells and springs that are sourced within coals in this area are likely to experience decrease in flow rate. Wells and springs in Wasatch are not expected to be substantially affected unless they are within 100 feet (vertically) of developed coal.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Surface Water				
Quantity	Perennial flows likely to develop in formerly ephemeral channels	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	High seasonal flows expected to rise	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
CBM Produced Water discharged to surface	476,216 acre-feet	179,171 acre-feet	270,781 acre-feet	181,807 acre-feet
Quality	Negligible changes in water quality of main stems.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	Concentrations of suspended sediment in surface waters likely to rise above present levels due to runoff from disturbed areas.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	SAR values and sodium concentrations may inhibit the use of irrigation on some tributaries.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	Evaporation may cause concentrations of salts and other metals in impoundments and surface drainages.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Surface Drainages	Erosion of surface drainages would occur due to increased flows.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	Channels are more likely to overbank during snowmelt due to increased flows from CBM discharges	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Surface Waterbodies	Reservoirs downstream likely would receive more water and could receive more sediment.	Numerous impoundments would serve as flood control structures during high seasonal flows.	Same as Alternative 1	Same as Alternative 1
	Springs may develop in drainages where infiltration is enhanced.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Surface Water Use	Increased availability of surface water for irrigation and other downstream beneficial uses.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	Potential reduction of flows by impoundments may diminish water availability to permitted water right holders downstream	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Physiography, Geology,Paleontology, and Minerals				
Paleontology	If Class 3, 4, or 5 formations are present in areas of disturbance, ground-disturbing activities could damage or destroy surface and sub-surface fossils.	Similar to Alternative 1, but with a higher potential due to a larger amount of disturbance.	Similar to Alternative 1, but with a higher potential due to a larger amount of disturbance.	Similar to Alternative 1, but with a reduced potential due to a smaller amount of disturbance.
Minerals	Would produce about 16 trillion cubic feet of CBM.	Same as Alternative 1	Same as Alternative 1	Would produce about 8 trillion cubic feet of CBM.
	Would produce about 220 million barrels of oil equivalent from the non-CBM wells.			Would produce about 100 million barrels of oil equivalent from the non-CBM wells.
Geological Hazards	Implementation is unlikely to cause noticeable ground subsidence or increase the potential for underground coal fires. Migration of some CBM could occur within the PRB as development of CMB occurs.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1. but to a smaller extent due to the smaller number of wells.
Soils				
Erosional effects from facilities located on soils with high wind erosion potential	Increased wind erosion due to removal of vegetation, excavation, and stockpiling of soil, especially in sandy soils. Approximately 25,474 acres in the short term and 13,403 acres in the long term would be disturbed on soils with a high wind erosion potential.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for wind erosion would increase slightly.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase impoundments, the potential for wind erosion would increase slightly, but increase would be less than in Alternative 2A.	All disturbance would be roughly cut in half. As Alternative 3 would employ the same water handling options as Alternative 1, effects would be similar but on a smaller scale.

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Erosional effects from facilities located on soils with high water erosion potential	Increased water erosion and sedimentation due to removal of vegetation, excavation, slope steepening and compaction, especially in clayey soils. Approximately 76,691 acres in the short term and 38,452 acres in the long term would be disturbed on soils with high water erosion potential. Soil loss estimates on these soils range from 3.4 to 18.7 tons/acre/year on bare soil and 0.5 to 2.6 tons/acre/year one year after reclamation.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for water erosion would increase slightly.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for water erosion would increase slightly, but increase would be less than in Alternative 2A.	All disturbance would be roughly cut in half. As Alternative 3 would employ the same water handling options as Alternative 1, effects would be similar but on a smaller scale.
Facility location on slopes greater than 25 percent	No facilities would be located on sloped greater then 25 percent Roads would be located to avoid steep slopes	No facilities would be located on sloped greater then 25 percent Roads would be located to avoid steep slopes	No facilities would be located on sloped greater then 25 percent Roads would be located to avoid steep slopes	No facilities would be located on sloped greater then 25 percent Roads would be located to avoid steep slopes
Effects on soil productivity	Reduction in soil productivity due to removal of vegetation, compaction, changes in salinity, excavation and stockpiling of soil. Approximately 206,777 acres in the short term and 103,800 acres in the long term would be disturbed on soils with high compaction potential, low revegetation potential, high salinity, or on Prime Agricultural soils.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for infiltration would be reduced but soil mixing and compaction would increase slightly.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for infiltration would be reduced but soil mixing and compaction would increase slightly. These changes in effects from Alternative 1 would be less than those experienced under Alternative 2A.	All disturbance would be roughly cut in half. As Alternative 3 would employ the same water handling options as Alternative 1, effects would be similar but on a much smaller scale.
Air Quality				
Compliance with Wyoming and federal ambient air quality standards	Yes	Yes	Yes	Yes

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Within range of States' hazardous air pollutant thresholds for maximum 8-hour concentrations	Yes	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
N-Hexane	Yes			
Benzene	Yes			
Toluene	Yes			
Ethylbenzene	Yes			
Xylene	Yes			
Formaldehyde	Above strictest threshold, but well within range			
Compliance with cancer risk threshold:		Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Benzene	Yes			
Formaldehyde	Yes			
Compliance with visibility thresholds in sensitive Class I and Class II areas:				
ΔdV > 1.0 dV	Up to 11.5 days	Up to 10.3 days	Up to 9.5 days	Up to 6.6 days
ΔdV > 0.5 dV	Up to 43.7 days	Up to 41.1 days	Up to 37.9 days	Up to 28.7 days
Vegetation				
Overall long-term vegetation displacement	128, 069 acres	146,963 acres	138,937 acres	52,231 acres
Sagebrush shrublands	40,007 acres	45,943 acres	43,517 acres	15,311 acres
Riparian, wetlands	3,327 acres	7,266 acres	3,402 acres	2,999 acres
Wildlife				
Big Game Species' Important Habitats				
Pronghorn Winter-yearlong range	Approx. 2 percent of this range would be disturbed in the Project Area over the long-term.	Same as Alternative 1	Same as Alternative 1	Approx. 1 percent of this range would be disturbed in the Project Area over the long-term.
White-tailed Deer Winter-yearlong and Yearlong Ranges	Less than 1 percent of both ranges would be disturbed in the Project Area over the long term. 100 percent of the winter-yearlong disturbance would occur in the Middle Powder River sub-watershed.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Mule deer winter-yearlong range	Approximately 1 percent of winter-yearlong range would be disturbed in the Project Area over the long-term — about 50 percent of which would occur in the Upper Powder River sub-watershed.	Less than 1 percent of winter-yearlong range would be disturbed in the Project Area over the long-term — about 50 percent of which would occur in the Upper Powder River sub-watershed.	Approximately 1 percent of winter-yearlong range would be disturbed in the Project Area over the long-term — approximately 58 percent of which would occur in the Upper Powder River sub-watershed.	Less than 1 percent of winter-yearlong range would be disturbed in the Project Area over the long-term 100 percent of which would occur in the Upper Powder River sub-watershed.

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Elk crucial winter range (Fortification Creek)	Approximately 3 percent of crucial winter range would be disturbed in Fortification Creek Management Area.	Approximately 4 percent of crucial winter range would be disturbed in Fortification Creek Management Area.	Same as Alternative 1	Same as Alternative 1
Big Game	Habitat fragmentation may alter big game use of habitats. Human disturbance may deter big game from otherwise suitable habitats to potentially lower quality habitats. Increased human activities may result in increased vehicle collisions, poaching and legal hunting success.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Raptors	Disturbance of ground nesting and prey habitats would occur. Increased human presence may alter raptor activity patterns. New utility poles may provide new perch sites for raptors. New aboveground lines and the potential for increased vehicle/wildlife collisions may increase mortality of local raptors. Habitat disturbance may alter local prey availability.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Sage and Plains Sharp-tailed Grouse	Habitat disturbance may occur in suitable nesting, feeding and brood rearing habitats; increased human activity may affect nesting, breeding, and brood rearing; Increased number of aboveground utility lines may result in increased number of grouse collisions if appropriate mitigation efforts are not implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Waterfowl	Habitat disturbance may be local beneficial or detrimental depending on local hydrological conditions. Benefits may include creation of new habitats and/or improvements of existing habitats. Production waters may also result in the elimination oar degradation of existing habitats. Indirect effects to aquatic plants and invertebrates may occur from exposure to elevated levels of salts and metals in production waters.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Aquatic Life	Surface discharge of produced CBM water in 10 sub-watersheds would potentially increase stream flows, increases in sedimentation, increases of salt concentrations in streams and ponds, and increases of heavy metal concentrations in streams and ponds. The largest amount of surface discharge (62% of 39,367 wells) is proposed under this alternative and would result in the most potential effects to aquatic species.	Surface discharge of produced CBM water in 10 sub-watersheds would potentially increase stream flows, increases in sedimentation, increases of salt concentrations in streams and ponds, and increases of heavy metal concentrations in streams and ponds. 25% of 39,367 wells are proposed to surface discharge under this alternative and would result in less potential effects to aquatic species than Alt. 1 and Alt. 2B.	Surface discharge of produced CBM water in 10 sub-watersheds would potentially increase stream flows, increases in sedimentation, increases of salt concentrations in streams and ponds, and increases of heavy metal concentrations in streams and ponds. 40% of 39,367 wells are proposed to surface dishcarge under this alternative and would result in more potential effects to aquatic species than Alt. 2A and less than Alt. 1.	Surface discharge of produced CBM water in 10 sub-watersheds would potentially increase stream flows, increases in sedimentation, increases of salt concentrations in streams and ponds, and increases of heavy metal concentrations in streams and ponds. The least amount of surface discharge (54% of 15,458 wells) is proposed under this alternative and would result in the smallest amount of potential effects to aquatic species of all Alternatives.
Threatened, Endangered, or Sensitive Species				
Black-tailed prairie dog	Project activities would directly affect individuals and suitable habitats, if appropriate mitigation measures are not implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Preble's meadow jumping mouse	No affects to this species due to assumed lack of occurrence within the Project Area.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Black-footed ferret	No affects to this species due to assumed lack of occurrence within the Project Area.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Bald eagle	Nesting and winter roosting may be affected by increased human activities and local habitat disturbance; and elevated traffic levels in the Project Area may increase eagle/vehicle collisions if mitigation measures are not implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Mountain plover	Human disturbance to suitable nesting and brood rearing habitats may affect this species.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Western boreal toad	No affects to this species due to assumed lack of occurrence within the Project Area.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Cultural Resources				
Total number of cultural resource sites that may be affected (based on known site densities):	3,288	3,604	3,435	1,696
General Distribution of Effects	The greatest anticipated effects would be in the Clear Creek, Upper Powder River, Crazy Woman Creek and Antelope Creek sub-watersheds. It is expected that 430 sites may be historic properties requiring some form of protection or mitigation.	The greatest anticipated effects would be in the Clear Creek, Upper Powder River, Crazy Woman Creek and Antelope Creek sub watersheds. It is expected that 470 sites may be historic properties requiring some form of protection or mitigation. Because of additional water handling facilities along the drainages, this alternative is likely to require more protective or mitigative measures than the other alternatives.	The greatest anticipated effects would be in the Clear Creek, Upper Powder River, Crazy Woman Creek and Antelope Creek sub watersheds. It is expected that 445 sites may be historic properties requiring some form of protection or mitigation.	The greatest anticipated effects would be in the Clear Creek, Upper Powder River, Crazy Woman Creek and Antelope Creek sub watersheds. It is expected that 220 sites may be historic properties requiring some form of protection or mitigation. Some infrastructure or support facilities may occur on federal surface for private development, but federal control over the identification and protection of historic properties would be minimal.
Land Use and Transportation				
Displacement of Rangeland Resources				
Short-term (acres)	229,591	248,485	240,459	108,406
Long-term (acres)	123,201	142,095	134,069	51,396
Additional Vehicle Trips				
Construction and Installation	3,129	3,630	3,366	1,059
Operation and Maintenance	790	790	790	506
Decommissioning & Reclamation	1,206	1,444	1,324	230
Change in average daily traffic relative to Existing Conditions	Over the entire Project Area, the average daily traffic is expected to increase more than 25 percent. The amount of increase on specific roads would vary greatly.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Visual Resources	317 wells, associated roads, and water handling facilities would be constructed on VRM Class II areas. Class II management objectives would be met if mitigation were successfully implemented. Management objectives for 3,939 wells and associated facilities for Class III areas and 4,530 wells and associated facilities for Class IV areas would be met. 437 wells and associated facilities would be constructed on TBNG areas managed with (Scenic Integrity Objectives (SIO) of Low. Desired conditions for SIO would be met, in that facilities can be visible if they are reasonably mitigated to blend and harmonize with natural features.	Wells and roads are same as Alternative 1. Water handling methods would disturb 6,682 additional acres. Class II management objectives would be met if mitigation were successfully implemented.	Wells and roads are same as Alternative 1. Water handling methods would disturb 6,682 additional acres as in Alternative 2A. However, a smaller number of acres would be disturbed by impoundments than Alternative 2A, with a proportionately smaller visual impact. Class II management objectives would be met if mitigation were successfully implemented.	No wells and associated facilities would be constructed on federal leases. Visual impacts from construction and operation would occur on State and private lands.
Recreational Resources	Construction activities would alter the recreational experience through a loss of solitude and the natural setting. After construction, the loss of solitude would be less because of greatly reduced traffic. Installation and operation of facilities would still affect the natural setting of the Project Area for the life of the project. Recreation in special management areas would not be affected. BLM and FS objectives for recreation would be met.	The effect on recreational opportunities from the construction of wells and associated facilities are same as Alternative 1. Water handling methods would disturb an additional 6,682 acres, resulting in a greater loss of solitude and the natural setting.	The effect on recreational opportunities from the construction of wells and associated facilities are same as Alternative 1. Water handling methods would disturb 6,682 additional acres as in Alternative 2A. However, a smaller number of acres would be disturbed by impoundments than Alternative 2A, with a proportionately smaller loss of solitude and the natural setting.	No wells and associated facilities would be constructed on federal leases. No impacts to recreation would occur on BLM lands or the TBNG. Loss of solitude and natural setting could occur on State and private lands.
Socioeconomics				
Effects to Employment	➢ 1,974 CBM workers and 67 non-CBM workers would be required. ➢ Employment would be greatest in first 10 years. ➢ Workers already exist in the community. ➢ Secondary employment would be sustained for a longer period than previously anticipated.	➢ 2,260 CBM workers and 67 non-CBM workers would be required. ➢ Employment would be greatest in first 10 years. ➢ Workers already exist in the community.	➢ 2,112 CBM workers and 67 non-CBM workers are required. ➢ Employment would be greatest in first 10 years. ➢ Workers already exist in the community.	➢ 607 new CBM and 30 non-CBM workers would be required. ➢ Employment would be greatest in first 10 years. ➢ Workers already exist in the community.

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Effects to Wages	➢ Combined annual payroll of the Companies would average an estimated $81.6 million. ➢ Over a 20 period $1.6 billion in personal income would be generated. ➢ Once the project is completed, a reduction in total annual income in the four counties would decline.	➢ Combined annual payroll of the Companies would average an estimated $93 million.	➢ Combined annual payroll of the Companies would average an estimated $87.1 million.	➢ Combined annual payroll of the Companies would average an estimated $25.5 million.
Effects on housing and community infrastructure	➢ Minor employment/population changes are anticipated because most employees are expected to be hired locally. ➢ Rental vacancy rates for 2000 were .2% lower than the average for Wyoming. Additional rental units may be constructed if existing supply of vacant rental units become exhausted. ➢ Due to the minor population influx, there would be minimal impact to water supply, wastewater systems, solid waste disposal, schools, fire protection, and medical facilities. ➢ The Proposed Action would result in increased traffic on roads and therefore road maintenance demands (see transportation).	➢ No change from proposed action ➢ Increase road maintenance due to construction and maintenance of water handling facilities.	Same as Alternative 2A	➢ Population change would not occur and there would be no negative housing or infrastructure effects.

Table S–2 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Royalties and taxes generated	➢ Federal Royalties = $3.1 billion ➢ State Royalties = $462 million ➢ Sales tax (4%paid to State, 1% paid to counties) = $76.6 million ➢ Severance (paid to State) = $2.4 billion ➢ Ad Valorem (paid to four counties) ➢ Campbell Co.= $1.5 billion ➢ Converse Co.= $32 million ➢ Johnson Co.= $690 million ➢ Sheridan Co.= $443 million	➢ Same royalties as Proposed Action ➢ More taxes would be generated due to the number and cost of water handling facilities.	Same as Alternative 2A	➢ $3.1 billon less in Federal Royalties ➢ $835 million less in Severance Tax ➢ $1.06 billion less in ad valorem tax ➢ Not drilling Federal wells may result in future negative production rates from Federal minerals, due to depletion from drilling on State and private lands.
Water handling cost to industry (all other development costs are constant among Alternatives 1, 2A, and 2B)	Surface Discharge = $954 million Infiltration = $1.05 billion Containment =$226 million LAD= $36 million Injection =$170 million TOTAL =$ 2.4 billion	Surface Discharge = $360 million Infiltration = $2.23 billion Containment = $263 million LAD = $115 million Injection = $184 million TOTAL = $3.1 billion	Surface Discharge = $1.2 billion Infiltration = $1.6 billion Containment = $239 million LAD= $115 million Injection = $184 million TOTAL = 3.3 billion	Surface Discharge = $363 million Infiltration = $478 million Containment = $98 million LAD = $16.7 million Injection = $73 million TOTAL = $1.03 billion
Non-water handling costs (Drilling, O & M, Reclamation)	$5.84 billion	$5.84 billion	$5.84 billion	$2.28 billion
Net Cost of Alternative	$8.28 billion	$8.96 billion	$9.17 billion	$3.31 billion

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Chapter 1
Purpose and Need

Chapter 1 — Purpose and Need

A group of oil and gas companies, collectively identified as the Powder River Basin Companies (Companies), has notified the U.S. Department of Interior, Bureau of Land Management (BLM) and U.S. Department of Agriculture, Forest Service (FS) of their intent to develop additional coal bed methane (CBM) resources in Wyoming's Powder River Basin (PRB). Implementation of this project would continue and expand development of CBM that has been occurring in the PRB over the last few years. In general, the Companies propose to:

- Drill, complete, operate, and reclaim almost 39,400 new natural gas wells and

- Construct, operate, and reclaim various ancillary facilities needed to support the new wells, including roads, pipelines for gathering gas and produced water, electrical utilities, and compressors.

The proposed project would occur in an almost 8,000,000-acre Project Area (Figure 1–1). This Project Area encompasses all or parts of Campbell, Converse, Johnson, and Sheridan counties and all or parts of eighteen 4th order watersheds (sub-watersheds). The proposed project would involve both public and privately owned lands. The public lands include lands administered by the BLM, National Forest System lands, and state lands. Additional information on land ownership and jurisdiction is presented in Chapter 3.

Development of Oil and Gas on Federal Lands in the Powder River Basin

Oil and gas activity in the PRB is generally classified into two categories: CBM and non-CBM. Development of CBM resources began in the mid 1980s. With advancements in technology, development and production of CBM has been increasing substantially since the mid 1990s. In contrast, production of non-CBM resources was relatively stable from 1986 through 1991, but has been declining sharply since 1991 (BLM 2001f). Overall, oil and gas development in the PRB, exclusive of CBM, is expected to slowly decline (BLM 2001f).

Four documents provide the primary guidance for the development of oil and natural gas from federal lands and minerals estate in the Project Area. Two of these documents are the resource management plans (RMPs) for the Buffalo and Casper Field Offices. The other two documents provide the primary guidance for the Thunder Basin National Grassland (TBNG), which is administered by the Medicine Bow National Forest. These documents are the Land and Resource Management Plan (LRMP) for the Medicine Bow National Forest and TBNG and the Final Environmental Impact Statement (EIS) and Record of Decision (ROD) for Oil and Gas Leasing on the TBNG, which were completed in 1985

MONTANA

WYOMING

SHERIDAN COUNTY

JOHNSON COUNTY

CAMPBELL COUNTY

CONVERSE COUNTY

Sheridan

Buffalo

Gillette

Wright

Thunder Basin National Grassland

UPPER TONGUE RIVER

MIDDLE POWDER RIVER

CLEAR CREEK

LITTLE POWDER RIVER

CRAZY WOMAN CREEK

UPPER POWDER RIVER

UPPER BELLE FOURCHE RIVER

MIDDLE FORK POWDER RIVER

SOUTH FORK POWDER RIVER

SALT CREEK

UPPER CHEYENNE RIVER

ANTELOPE CREEK

DRY FORK CHEYENNE RIVER

LIGHTNING CREEK

MIDDLE NORTH PLATTE CASPER

LEGEND

- 4th Level Watershed Boundary
- Perennial Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

N

10 0 10 20 Miles

10 0 10 20 30 Kilometers

Sub-Watersheds

1--Little Bighorn River

2--Little Missouri River

3--North Fork Powder River

4--Salt Creek

WYOMING

Project Area

Existing CBM Well Location Data Provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland Data Provided by the US Forest Service. All other Data Provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 1-1 PROJECT LOCATION MAP	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/14/01	ArcView File: C:\1011_v1\data\maps.apr Layout--Project Location Map
	DRAWN BY: MSH

and 1994, respectively. In July 2001, the FS released a Final EIS and proposed LRMP for the TBNG to replace the 1985 plan. However, release of the ROD is not expected until early in 2002. Thus, the 1985 LRMP is still in effect.

In addition to the four guidance documents, the BLM and FS have conducted several specific analyses on the development of CBM on federal lands. They include the American Oil and Gas Marquiss Field Coal Bed Methane Project EA (BLM 1992a), Exxon Pistol Point Coal Bed Methane Project Environmental Assessment (BLM 1992b), Gillette South Coalbed Methane Project Draft EIS (BLM 1995b) and Final EIS (BLM 1997a), Lighthouse Coal Bed Methane Project Environmental Assessment (BLM 1995c), Gillette North Coal Bed Methane Project Environmental Assessment (BLM 1996), Wyodak CBM Draft and Final EISs (BLM 1999c and 1999d), and Wyodak Drainage CBM Environmental Assessment (BLM 2000). These documents and their associated decision documents specifically address the development of CBM that has been occurring on federal lands since 1992.

Purpose of and Need for the Proposed Action

The Companies hold valid federal, state, and private leases for oil and natural gas in the Project Area. The leases have created contractual and property rights for the Companies from the United States, the State of Wyoming, and private mineral owners to develop oil and natural gas resources. The purpose of the Companies' proposal is to extract, transport, and sell oil and natural gas at a profit from the portions of the Project Area leased by them.

The BLM and FS reeognize the extraetion of oil and natural gas is essential to meeting the Nation's future needs for energy. As a result, private exploration and development of federal oil and gas reserves are integral parts of the agencies' oil and gas leasing programs under the authority of the Mineral Leasing Act of 1920, as amended by the Federal Land Policy and Management Act (FLPMA) of 1976 and the Federal Onshore Oil and Gas Leasing Reform Act of 1987. The BLM and FS' oil and gas leasing program encourages the development of domestic oil and gas reserves and reduction of the United States' dependence on foreign sourees of energy.

As a result of the contraetual and property rights created by the valid leases, the direetion eontained within the BLM's oil and gas leasing program, the status of the BLM's two RMPs and the FS' LRMP and Oil and Gas Leasing Final EIS, the BLM and FS need to evaluate the level of development of oil and natural gas in the Projeet Area over the next ten years. Specifically, the BLM and FS need to address the Proposed Action and reasonable alternatives to that action direetly, indireetly, and eumulatively.

When the four primary guidance documents identified above were prepared, the levels of development for oil and natural gas anticipated at the time were less than levels currently proposed by the Companies and the ageneies' current Reasonably Foreseeable Development (RFD) Seenario (Appendix A). In particular, the current and proposed levels of development of CBM were not specifically defined. Consequently, the BLM and FS need to evaluate conformance of the

Proposed Action and alternatives to that action with the Buffalo RMP, Casper RMP, Medicine Bow National Forest's LRMP, and the TBNG Oil and Gas Leasing EIS and, if necessary, amend these documents to address the additional development comprising the selected alternative.

Therefore, this EIS serves five purposes. First, it provides the basis to analyze and disclose the impacts of the level of development proposed within the Project Area (both under the Proposed Action and RFD scenario). It addresses the effects of implementing a level of development of oil and natural gas within the Project Area that is conceptual in nature. The wells, roads, pipelines, and ancillary facilities depicted in this EIS represent a proposed level of development and tentative locations for these facilities. The final location for each component would be determined through future site-specific analyses that the BLM and FS would require for each facility. These analyses would occur when the Companies file applications for each component, such as an Application for Permit to Drill (APD), a FS Special Use Permit (SUP), or a BLM Right-of-Way (ROW) Grant.

Second, this EIS provides the means for the BLM and FS to provide federal minerals to meet the Nation's energy needs. It also facilitates protection of the financial interest of the United States by preventing the drainage of federal minerals.

Third, the EIS identifies mitigation measures to address issues and conditions of approval for the subsequent site-specific applications for individual locations. These measures and conditions would be incorporated into the process during permitting of the individual facilities (again through the APD, SUP, or ROW Grant processes).

Fourth, the FS will use the analysis documented in this EIS to revise the 1994 leasing decisions on those portions of the TBNG that have potential for CBM development (about 80,000 acres of National Forest System lands). The outcome of the impact analysis will be assessed against current lease stipulations to determine whether the current LRMP lease stipulations need to be modified or if new stipulations need to be developed. This decision would revise previous decisions made by the FS for the TBNG.

Finally, similar to the FS, the BLM is also using the outcome of the impact analysis to review the existing RMP decisions. This includes areas open and closed to leasing, lease stipulations, and authorized mitigation measures. This review will determine whether: (1) changes to current designations of areas open and closed to oil and gas leasing need to be made, (2) current RMP lease stipulations need to be modified or new stipulations need to be developed, and (3) new mitigation measures need to be enacted. Should items one, or two, or both be determined to be necessary for either of the two RMPs, an amendment would be needed. If the decision maker determines the BLM needs to amend one or both RMPs, the analyses contained in this EIS will provide the basis for amending the RMPs. The Final EIS and ROD would serve as amendments to the Buffalo RMP and Casper RMP.

NEPA Process, Including Tiering and Decision Making

The National Environmental Policy Act (NEPA) and directives by the Council on Environmental Quality (CEQ) require the BLM and FS to analyze proposed actions involving federal lands and leases in terms of their potential effects on the human environment. Furthermore, regulations implementing the Mineral Leasing Act of 1920 require the BLM and FS to review and act on APDs and attached Surface Use Plans of Operations (SUPO) and to decide on the requirements for surface occupancy provided by the SUPO. The BLM and FS also issue ROW Grants and SUPs, respectively, to construct and operation linear transportation facilities, such as roads and pipelines, across federal lands under Title V of FLPMA and the Mineral Leasing Act.

The analysis of effects to the human environment discloses the potential environmental consequences of proposed actions and alternative actions. Another responsibility of the BLM and FS is establishing provisions for ensuring the reclamation of facilities and disturbed lands if an oil and gas operator would fail to complete adequate reclamation efforts. Bonds are required for oil and gas operations on federal leases to indemnify the government for safe rehabilitation, royalty payments, and civil penalties. Bonds also are required for ROWs on federal lands.

The BLM, Buffalo Field Office in Buffalo, Wyoming is the lead federal agency responsible for conducting the NEPA analysis and preparing this EIS. The FS (Medicine Bow National Forest) is a cooperating agency and is responsible for protecting non-mineral resources on National Forest System lands in the TBNG. The development of the Proposed Action and the alternatives was conducted by an oversight team consisting of the BLM, FS, State of Wyoming agencies, five conservation districts, and the four counties. Wyoming agencies specifically designated to represent the State as a cooperating agency on this team included the Office of Federal Land Policy, Department of Environmental Quality (WDEQ), the Wyoming Oil and Gas Conservation Commission (WOGCC), and Wyoming State Engineer (WSEO). The State also designated another eight agencies to assist these four agencies.

This document provides the responsible agencies with information upon which to base a final decision that considers factors relevant to the proposal. Scoping issues and concerns raised by the public and agencies drove the development of alternatives and focused the environmental impact analysis. This EIS documents (1) the analysis of effects that could result from implementation of the Proposed Action or alternatives and (2) the development of environmental protection measures necessary to reduce or eliminate environmental consequences.

The regulations implementing NEPA encourage tiering in EISs. Tiering is the process of referencing information presented in other previously prepared NEPA documents, such as EISs to minimize repetition. This EIS is specifically tiered to the four guidance documents identified previously.

Finally, this EIS is not a decision document; it documents the process used to analyze the potential environmental consequences of implementing the proposed oil and gas development project and alternatives to the Proposed Action. The decisions about the proposed project will be documented in separate RODs (one for the BLM and one for the FS) signed by the agency's responsible official. The BLM and FS' decisions will apply to federal lands and leases administered by both agencies. Decisions by other jurisdictions to issue or not to issue approvals related to this proposal may be aided by the disclosure of effects available in this analysis.

Decisions to be Made Based on this NEPA Analysis

The decision makers for the BLM (Wyoming State Director) and FS (Medicine Bow-Routt National Forests Supervisor) will decide based on the analysis documented in this EIS, whether current RMP or LRMP lease stipulations are adequate or if new stipulations need to be developed. They will determine whether any changes to current designations of areas open or closed to oil and gas leasing need to occur. Also, they will determine if new mitigation measures need to be adopted, and if any of the management plans need to be amended.

Decisions to be Made Following this NEPA Process

The RODs associated with this EIS will not be the final review or the final approvals for all actions associated with the PRB Oil and Gas Project. Although the RODs would approve a maximum level of oil and gas development and its general location, the BLM and FS must analyze and approve each component of the project that involves the disturbance of federal lands on a site-specific basis. The method used to evaluate each surface-disturbing activity is the APD or ROW Grant/SUP, which would be required before any construction can occur.

The APD includes a surface use program and a drilling plan. The detailed information to be submitted under each program is identified in Onshore Oil and Gas Order No. 1 and 43 Code of Federal Regulations (CFR) 3162.3. An on-site inspection of the locations proposed for the well, access road, pipelines, and other areas of proposed surface use would be conducted before approval. The inspection team would include the BLM, FS (if construction would occur on National Forest System lands), the lessee or its designated representative, the primary drilling and construction contractors, and federal grazing lessees. For inspections involving split estate lands (lands with private surface ownership and federal minerals ownership), the BLM also would invite the surface owner to attend.

The purpose of the on-site inspection would be to identify potentially sensitive areas and the environmental consequences associated with the proposal at each specific location and site-specifically apply the methods needed to mitigate those effects. The on-site could include site-specific surveys for cultural resources or threatened or endangered species, if the potential for occurrence of these re-

sources exists on or near the proposed disturbance. After the site inspection, the APD may be revised or site-specific mitigation may be added as Conditions of Approval to the APD, consistent with applicable lease terms, for the protection of surface or subsurface resource values near the proposed activity. These may include adjusting the proposed locations of well sites, roads, and pipelines; identifying the construction methods to be employed; and identifying reclamation standards for the lands.

Since the issuance of the ROD for the Wyodak Final EIS, the BLM has been requiring that CBM projects be submitted as Plans of Development (POD). A POD is a group of wells and their supporting infrastructure (e.g., roads, pipelines, power lines, water discharge points, booster stations, and compressor stations) for a given geographic area or sub-watershed. The POD helps the operators develop a logical, economical, environmentally sound CBM project that the BLM can efficiently process and approve.

The BLM is responsible for conducting an environmental analysis on BLM lands (BLM surface ownership and all federal minerals ownership), preparing the documentation, and providing mitigation measures to protect surface resources for APD approval. The FS would have similar responsibilities on National Forest System lands. The BLM is responsible for approval of the drilling program, protection of ground water and other subsurface resources, and final approval of the APD on both BLM and National Forest System lands.

Access roads and pipelines on BLM-managed land outside the applicant's lease would require a ROW Grant. Likewise, facilities on National Forest System lands would require an SUP. The APD could be acceptable as an application for a ROW Grant or SUP for off-lease facilities, if it provides sufficient detail of the entire proposal.

After drilling, routine well operations would not require approval. However, the BLM would have authority for approving a variety of related activities. Any changes to an approved APD, certain subsequent well operations, and all subsequent new surface disturbances, such as workover pits, would require prior approval. Complete details of subsequent well operations are contained in 43 CFR 3162.3–2. Disposal of produced water from Federal leases would require prior approval, as outlined in Onshore Oil and Gas Order No. 7. The BLM also would approve plugging and abandonment of wells, hydrogen sulfide protection measures (if necessary), gas venting, gas flaring, and certain measures for handling production.

Authorizing Actions

A variety of federal, state, county, and local permitting actions would be required to implement any of the alternatives. Table 1–1 lists the major federal and state permit, approvals, and consultations likely to be required for the PRB Oil and Gas Project. However, the list is not necessarily complete. In addition, various county and local permitting and approval actions would be required for any alternatives selected by the decision makers.

Table 1–1 Major Federal and State Permits, Approvals, and Consultations Potentially Required for the PRB Oil and Gas Project

Issuing Agency/Permit Approval Name	Nature of Permit Action	Applicable Project Component
Federal Permits, Approvals, and Authorizing Actions		
USDI – Bureau of Land Management		
Permit to Drill, Deepen, or Plug Back (APD), CBM Plan of Development (POD), and Sundry Notice, plugging and abandonment, venting, and flaring	Controls drilling and production for oil and gas on federal onshore leases.	Wells and production facilities.
Rights-of-Way Grant and Temporary Use Permit	Right-of-way grant on BLM-managed lands.	Oil and gas pipelines, roads, facilities, etc. on BLM-managed lands.
Cultural Resource Use Permit	Archaeological surveys and limited testing on public lands. Archaeological data recovery (excavation) of sites on public lands.	All surface-disturbing activities.
Pesticide Use Permit	Control of pests.	Wells, roads, and ancillary facilities.
National Noxious Weed Act Compliance	Controls noxious weeds.	Any occurrence of noxious weeds on or near project facilities.
Material Sales	Sales of sand, gravel, and riprap.	Construction activities.1
USDA – Forest Service		
Special Use Permit	Surface disturbance on FS-managed lands.	Wells, roads, pipelines, and facilities on FS-managed lands.
Special Use Permit (Cultural Resources)	Archaeological surveys and limited testing on public lands. Archaeological data recovery (excavation) of sites on public lands.	All surface-disturbing activities.
USDI Fish and Wildlife Service		
Endangered Species Act Compliance (Section 7)	Protects threatened and endangered species.	Any activity potentially affecting species listed as or proposed for listing as threatened or endangered.
Migratory Bird Treaty Act	Protects migratory birds.	All surface-disturbing activities.
Bald Eagle Protection Act	Protects bald and golden eagles.	All surface-disturbing activities.
Advisory Council on Historic Preservation		
Cultural Resource Compliance (Section 106)	Protects cultural and historic resources. Coordinated with the Wyoming State Historic Preservation Officer (SHPO).	All surface-disturbing activities.
U.S. Department of Army Corps of Engineers		
Permit to Discharge Dredged or Fill Material (Section 404 Permit)	Authorized placement of dredged or fill material in waters of the United States or adjacent wetlands.	All surface-disturbing activities.
U.S. Department of Transportation		
Construction and operation of natural gas pipelines.	Prescribes minimum safety requirements for pipeline facilities and the transportation of gas, including pipeline facilities.	Natural gas pipelines.
State Permits, Approvals, and Authorizing Actions		
Wyoming State Engineer's Office		
Permit to Appropriate Ground Water	Registering ground water rights for all uses, except stock and domestic.	Wells.

Table 1–1 Major Federal and State Permits, Approvals, and Consultations Potentially Required for the PRB Oil and Gas Project

Issuing Agency/Permit Approval Name	Nature of Permit Action	Applicable Project Component
Permit to Construct a Reservoir	Ensures the safety and structural integrity of water storage facilities.	Water storage facilities.
Permit to Appropriate Surface Water	Applications for any request for putting surface waters of the state to a beneficial use.	Facilities to transport or store surface waters.
Permit for Land Application of Produced Water	Authorizes the application of produced water to lands for disposal.	Land Application Disposal facilities.
Permit to Appropriate By-product Water for Additional Beneficial Uses	Authorizes the use of by-product water for beneficial uses.	Facilities to dispose of produced water when used for additional beneficial uses, such as stock watering.
Wyoming Department of Environmental Quality		
National Pollutant Discharge Elimination System (NPDES) Individual Coal Bed Methane Permit	Authorizes discharge of produced water to surface waters of the state.	Any point-source surface discharge.
NPDES General Permit for Storm Water Discharges	Controls discharge of storm water pollutants associated with industrial and construction activities.	Construction activities disturbing five or more surface acres of land and gas production facilities that have had a discharge of a reportable quantity
New Source Review (NSR) Permit (non-Prevention of Significant Deterioration)	Controls emissions from new or modified sources.	All pollutant emission sources and construction activities, including compressors and larger portable diesel and larger gas (≥ 300 hp) generators.
Fugitive Dust Control	Control fugitive dust emissions.	Construction of facilities and vehicle traffic.
Wyoming Department of Transportation		
Access Permit	Authorizes access roads tying into state or federal highways.	All project roads
Wyoming Oil and Gas Conservation Commission		
Permit to Use and Construct Earthen Pit for Temporary Use or for Reserve Pit	Authorizes the construction and use of an earthen pit for oil and gas wells.	Oil and gas wells.
Permit to Drill/Deepen/Plug Back	Authorizes the drilling, deepening, or plugging of oil and gas wells.	Oil and gas wells.
Permit to Use and Construct Earthen Pit for Retention of Produced Water	Authorizes the construction and use of of an earthen pit for the storage and evaporation of produced water.	Oil and gas wells.
Wyoming State Historic Preservation Office		
Section 106 Cultural Resource Consultation	Determines significance of cultural resources potentially affected by surface-disturbing activities.	All surface-disturbing activities.

Chapter 2
Public Participation, Issue Identification, and Alternatives

Chapter 2 — Public Participation, Issue Identification, and Alternatives

This chapter covers five primary topics. First, it describes the process used to obtain the public's concerns and identifies the issues raised by the public. Then, it describes the process used to develop the alternatives considered in this analysis. Third, it describes the project alternatives analyzed in detail. The specific features of these alternatives are fully described. Fourth, it identifies each alternative dropped from detailed consideration and briefly describes the reasoning for the exclusion. Finally, it summarily presents, in comparative form, the components and environmental effects of the alternatives analyzed in detail and identifies the agencies' preferred alternative.

Public Participation

The BLM and FS consider public participation a crucial component in defining the scope of the environmental analysis presented in this EIS. Consequently, the agencies worked to ensure the public was informed about the Companies' proposal and the opportunities available for participating in the environmental process.

The agencies first informed the public of the BLM and FS' intent to conduct an environmental impact analysis of oil and gas development within the PRB during May and June 2000. In May, the agencies prepared and mailed almost 900 copies of a Scoping Letter, which solicited comments from its readers to assist the BLM and FS in identifying the specific issues and concerns the agencies should address in the analysis and document in the EIS.

On 21 June 2000, formal scoping for the analysis began with publication in the Federal Register of a Notice of Intent (NOI) to prepare an EIS. The BLM published additional notices in the Federal Register to correct mistakes in the first NOI and to invite the public's participation in the analysis and potential amendments to the Buffalo and Platte River Resource Management Plans.

The BLM also sent a news release to more than 60 media outlets (e.g., newspapers, radio stations, and television stations) in Wyoming and Montana. This news release announced the agencies' intention to prepare an EIS and identified the public meetings. Additionally, several newspapers prepared stories on the project.

In addition to the publications and mailings, the agencies held four public meetings to discuss the proposal and receive comments from the public. The first meeting was held in Sheridan, Wyoming on 6 June 2000. The second and third meetings were held in Buffalo, Wyoming and Gillette, Wyoming on 7 and 8 June 2000, respectively. The final meeting was held in Douglas, Wyoming on 12 June

2000. At all meetings, the proposal was described and attendees were provided the opportunity to ask questions and submit comments.

Finally, the BLM and FS have been keeping the public informed of the analysis' status through a periodic newsletter and project-specific web site (www.prb-eis.org). The BLM also placed project information on its Wyoming web site.

Issue Identification and Issue Statements

The BLM and FS reviewed and analyzed the comments they received during the scoping process. Public response to the notices and meetings included 74 letters, comment forms, and e-mails. Also, a total of 106 people attended one or more of the four public meetings.

The agencies' process for identifying issues involved three overall steps. First, specific comments were arranged into groups of common concerns. Next, a primary issue statement was prepared for each group of comments. Finally, the issue statements were evaluated for applicability to this NEPA analysis.

The analysis of comments initially identified 27 issues. Eighteen of these 27 issues were identified as key or significant issues (see November 2000 Scoping Summary to review nonsignificant issues). These issues were used to define the scope of this NEPA analysis. These key issues were used to analyze environmental effects, prescribe mitigation measures, or both. Issues are "significant or key" due to the extent of their geographic distribution, the duration of their effects, or the intensity of interest or resource conflict. The determination of an issue's significance is different than and separate from any determination of the significance of an environmental consequence. The other nine issues were not identified as key because they involved standard parts of a NEPA analysis (e.g., the analysis must consider an adequate range of alternatives) or the agencies determined they were beyond the scope of this NEPA analysis. The 18 key issues that comprised the overall scope of the NEPA analysis are:

Issue 1: The effects of the additional development of oil and gas resources on aquifers present in and down gradient of the project area.

Respondents expressed concerns about the effects on local aquifers of depressurizing coal beds through the pumping of water. Landowners identified concerns about the pumping causing them to lose the use of their existing water wells, which are sources of water for the consumption of both humans and livestock. Concerns include direct losses (loss of water wells drilled into coal aquifers) and indirect losses (loss of water wells drilled into aquifers located above, but connected with, the coal beds). Some respondents also are concerned that pumping water from the coal seams could increase the potential for subsidence, which could adversely affect aquifers. Because the availability of uninterruptible supplies of ground water are important to the economic well-being of landowners in the project area, respondents requested ground water modeling specifically to address the rates of pumping, horizontal and vertical movement of ground water, recharge of aquifers, interdependence of aquifers, permeability of overburden and layers between the coal seams, and the cumulative effects of depletions due to oil and gas and depletions resulting from coal mining.

Issue 2: The effects of the additional development of oil and gas resources on the quantity and distribution of surface water in and downstream of the project area.

Many respondents expressed concerns about the volumes of surface water the Companies would discharge from CBM wells into drainages across the project area. Considering the potential number of wells and the rates projected for the discharge of produced water from each well, discharges could be too great for some channels to handle, which would cause sheet flows across lands instead of flows constrained to the channels of streams. These volumes could overwhelm the Companies and landowners' abilities to contain or control the flow of water across properties, which would affect the landowners' uses of the properties. This problem already is evident on some properties where channels have been replaced with spreader dikes. The additional volumes of water may also affect the operation of reservoirs in and downstream of the project area. Consequently, respondents thought the analysis should determine and disclose the volumes of produced water expected by watershed (a single "type curve" for production throughout the project area should not be used). Additionally, they suggested the development of detailed watershed plans specifically to address these concerns.

Issue 3: The effects of the additional development of oil and gas resources on the quality of surface water in and downstream of the project area and the potential to adversely affect current uses of those surface waters.

Many respondents expressed concerns about the quality of produced water the Companies would discharge into surface drainages and how that produced water would affect the existing quality of surface water and other resources that depend on that water. They cited incidental observations suggesting produced water may impair surface waters by introducing metals (e.g., iron, manganese, and barium), increasing the SAR, and increasing sedimentation; kill vegetation (e.g., sagebrush and grass) with which it comes into contact; adversely affect lands and crops irrigated with it; adversely affect sources of municipal water; and adversely affect wildlife and livestock. Produced water also may alter the temperatures of streams receiving the discharges. Concerns were greatest for rivers classified as impaired (i.e., the Tongue, Powder, and Belle Fourche rivers in Montana and South Dakota). Finally, respondents identified a need for long-term monitoring of the quality of produced water discharged to surface waters.

Issue 4: The effects of the additional development of oil and gas resources on the project area's geology, geologic hazards, and the extraction of other mineral resources present in the project area.

Respondents expressed concerns about the effects the additional development of oil and gas resources may have on the extraction of other minerals in the project area, particularly coal. Some questioned how the extent of development considered in the alternatives could adversely affect the mining companies' ability to mine coal. Also, they questioned whether the extraction of ground water from the coal seams could increase the potential for subsidence such that it could adversely affect the ability to mine coal or other minerals or whether any reinjection of produced water could increase the potential for earthquakes. Areas prone to landslides need to be considered. Respondents thought the inclusion of a detailed map of the project area's geology would help readers comprehend the situation more completely.

Issue 5: The effects of the additional development of oil and gas resources on soils in and downstream of the project area.

Respondents expressed concerns about the project increasing the loss of topsoil through erosion (via both water and wind), particularly where the Companies would discharge the produced water. Other concerns include the project's potential for increasing the compaction of soils and adversely affecting local soils' structure and fertility.

Issue 6: The effects of the additional development of oil and gas resources on air quality and visibility.

Respondents expressed concerns about the effects of the additional oil and gas development on the project area's visibility and quality of air. Construction of new roads and facilities and increases in traffic would result in increases in particulates. Construction of new gas-fired compressors and increases in the volumes of traffic would result in additional gaseous emissions. These increases could impair the quality of air and visibility, which also may affect the health of humans, wildlife, and livestock (e.g., dust pneumonia). Concern also was expressed about long-term venting of methane and its potential effects to air quality. Respondents were concerned about the alternatives' effects on visibility at Class I areas within the project area's effective airshed.

Issue 7: The effects of the additional development of oil and gas resources on vegetation in and downstream of the project area, including wetlands and riparian areas.

Respondents expressed concerns that the additional development of oil and gas resources would adversely affect the project area's vegetation generally and wetlands and riparian areas specifically. Construction of facilities would directly disturb vegetation over both the short term and long term. Changes in the volumes and rates of surface water flows could alter the distribution of vegetative cover types. Wetlands and riparian areas would be most susceptible to changes in the quantity and quality of surface waters. Areas with intermittent flows may experience perennial flows as development expands. Also, disturbances in the project area could increase the potential for the spread of noxious plants at the expense of displacing native vegetation.

Issue 8: The effects of the additional development of oil and gas resources on species of wildlife and their habitats (particularly key species and habitats).

Respondents expressed concerns that the additional oil and gas development would directly, indirectly, and cumulatively affect species of wildlife and their habitats. Species or groups of species for which they identified specific concerns include raptors, sage grouse, sharp-tailed grouse, deer, elk, antelope, and waterbirds. The effects that concerned most respondents include the direct loss of habitats (particularly crucial winter ranges for large deer, elk, and antelope), disturbance of animals by humans (including additional noise), fragmentation of habitats (primarily through the construction of roads, well pads, and fences), introduction of new perches for raptors, increases in hunting pressure, increases in harassment, and project-induced increases in mortality (e.g., poaching, trapping, poisoning, and roadkills).

Issue 9: The effects of the additional development of oil and gas resources on fisheries and aquatic habitats.

Respondents expressed concerns about the potential direct, indirect, and cumulative effects of the additional oil and gas development on fisheries and the aquatic habitats upon which they depend. The discharge of produced waters could affect fisheries and aquatic habitats by altering the quantity, quality, and temperature of waters in steams and rivers. These concerns were greatest for streams and rivers containing special-concern species of fish and rivers classified as impaired (i.e., the Tongue, Powder, and Belle Fourche rivers in Montana and South Dakota).

Issue 10: The effects of the additional development of oil and gas resources on the project area's ecological integrity and biological diversity.

Respondents expressed concerns that additional oil and gas development could adversely affect the natural ecological integrity in and downstream of the project area. The additional oil and gas development could alter the project area's biological diversity by changing species composition, abundance, and the distribution of plants and animals. Because different species of wildlife require different levels of habitat diversity, these changes are important to a number of species. Areas specifically identified for being of importance to the conservation of biological diversity in the region include the Little Powder River (river banks and adjacent upland sites), Powder River, and Upper Antelope Creek (including the rolling uplands).

Issue 11: The effects of the additional development of oil and gas resources on special-concern species, particularly threatened, endangered, candidate, or sensitive species of plants and animals.

Respondents expressed concerns that the additional oil and gas development could adversely affect special-concern species, including species of plants and animals listed as threatened or endangered, proposed for or identified as candidates for listing as threatened or endangered, or identified as sensitive by the BLM or Regional Forester. Species of particular concern to respondents include the black-footed ferret, bald eagle, mountain plover, Ute ladies'-tresses orchid, black-tailed prairie dog, swift fox, sturgeon chub, pallid sturgeon, shovelnose sturgeon, and western silvery minnow. Some respondents noted the need for the analysis to comply with Section 7 of the Endangered Species Act (ESA).

Issue 12: The effects of the additional development of oil and gas resources on rangeland resources and grazing operations.

Respondents expressed concerns about the effects of the additional development of oil and gas resources on rangeland resources and grazing operations. The potential loss of water wells for livestock, changes in grazing patterns due to long-term flooding of hayfields and winter ranges, and the consumption of lower-quality produced water by livestock, are the primary concerns. Additional concerns included fencing, the harassment of livestock, and the potential for project-induced health problems (e.g., dust pneumonia and undernourishment).

Issue 13: The effects of the additional development of oil and gas resources on cultural resources, paleontological resources, and Native Americans.

Respondents expressed concerns about the potential for the additional development of oil and gas resources to adversely affect cultural resources, paleontologi-

cal resources, and Native Americans. In addition to the direct and indirect disturbances associated with the construction of facilities, the discharge of produced waters could increase streamflows sufficiently to disturb cultural resources present in steambeds. Also, the Northern Cheyenne Indian Reservation, which is in the Upper Tongue River watershed immediately downstream of the project area, may experience adverse effects from the project.

Issue 14: The effects of the additional development of oil and gas resources on recreational opportunities and the recreational experience.

Respondents expressed concerns about the degree to which the additional development of oil and gas resources would alter the existing recreational setting and experience. Activities would add new sources of noise that could diminish the recreational experience. New roads would provide access for vehicles and promote an increase in human activity. Also, implementation of the additional development could adversely affect the wildlife-related recreation (e.g., viewing wildlife, hunting wildlife, and fishing). However, the development of certain facilities, such as reservoirs for impounding produced water, could enhance some wildlife-related recreational opportunities by providing areas for viewing wildlife, hunting waterfowl, or public fishing.

Issue 15: The effects of the additional development of oil and gas resources on the project area's aesthetics.

Respondents expressed concerns about the effects of the additional development of oil and gas resources on the project area's aesthetics. Levels of noise would increase with the addition of compressors, pumps, and traffic. Human activity would become much more visible with the addition of many miles of roads, pipelines, power lines, and fences. These additional features would affect the area's visual quality and cause conflicts with the BLM and FS' visual management systems, which could affect the agencies' management of federal lands in the project area.

Issue 16: The effects of the additional development of oil and gas resources on the local economy.

Respondents expressed concerns about the effects of the additional development of oil and gas resources on the local economy. Some felt the additional development would cause more damage to the local economy over the long term than any monetary gain obtained from the leases, royalties, taxes, and jobs. Of particular concern is the discharging of large amounts of ground water onto the ground surface because ground water is considered vital to the economic well being of the rural communities and it should be attributed some economic value in the analysis. Also of concern, are the effects on the availability of affordable housing, an adequate community infrastructure to support an influx of people (e.g., law enforcement, medical facilities, schools, and transportation network), and property values. Some respondents identified concerns about the potential for the project to affect employment and opportunities for employment in Montana by attracting workers away from agriculture and other traditionally lower paying occupations.

Issue 17: The effects of the additional development of oil and gas resources on human health and safety.

Several respondents expressed concerns about potential dangers or threats to human health and safety with the additional development of oil and gas resources. These concerns included the potentials for and the effects of methane migrating into residences and water wells and seeping out at outcrops (killing vegetation and wildlife), spontaneous combustion of depressurized coals resulting in uncontrollable underground fires, contamination of drinking water aquifers by the chemicals used in hydraulic fracturing, ruptures of pipelines, spills, illegal dumping, and the application of treatments to roads (e.g., magnesium chloride).

Issue 18: The analysis needs to include an analysis of environmental justice.

Concerns were expressed about the potential of the additional development of oil and gas resources to affect Native American Tribes in Montana. Of particular concern are the Northern Cheyenne and Crow. At a minimum, an analysis of environmental justice should be completed for these Tribes.

Process Used to Develop Alternatives

The process of developing alternatives to the Proposed Action involved four steps. First, the agencies conducted project scoping to identify the key issues of concern. This scoping involved both internal agency and public concerns. It also considered environmental and project-design elements.

The second step consisted of formulating alternatives to the proposal. Each alternative had to meet the purpose of and need for the project. Typically, driving issues are identified that help the agencies define what changes need to be made to avoid, eliminate, reduce, minimize, or mitigate effects that would result from implementing the Proposed Action. The agencies identified three issues (Numbers 2, 3, and 6) as the potential driving issues for this EIS.

The third step involved screening the potential alternatives for reasonableness. The NEPA process requires that alternatives evaluated in detail be reasonable. The regulations for implementing NEPA provide a discussion of the need for reasonable alternatives in the NEPA process (40 CFR 1500.1(e) and 1502.14). Also, CEQ's 40 Most Asked Questions about NEPA (Question 2a) state, in part, that "reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense" (CEQ 1981).

Based on this direction, the agencies focused their screening of alternatives on technical, environmental, and economic feasibility. Technical considerations included the feasibility of constructing and operating the facilities. Environmental considerations included the potential for significant effects and the feasibility of successfully mitigating the effects of the alternative. Economic considerations included potential costs and benefits of implementing the alternative.

Finally, unreasonable alternatives were dropped from detailed consideration. If an alternative did not pass the technical, environmental, and economic screening for feasibility, it was not considered any further in the analysis.

Alternatives Considered in the NEPA Analysis

The process described above resulted in the development of several alternatives that specifically responded to one or more key issues. Although a variety of alternatives was developed, not all of the alternatives were analyzed in detail. Some were determined to be unreasonable during the feasibility screening. Others were eliminated after initial analysis indicated they were not reasonable or conditions changed, such as the signing of the Interim Memorandum of Cooperation (MOC) by Montana and Wyoming (Appendix B) to document their commitments and intent to protect and maintain water quality conditions in the PRB within Montana.

The alternatives developed for this NEPA analysis are described in two overall sections. The alternatives analyzed in detail are described first. A section on Alternatives Considered but Eliminated follows the alternatives analyzed in detail (beginning on page 2–62).

Alternatives Analyzed in Detail

Three alternatives were analyzed in detail. They include the Proposed Action (Alternative 1) and No Action Alternative (Alternative 3). Alternatives 2A and 2B are the Proposed Action with Reduced Emission Levels and Expanded Disposed Water Handling Scenarios. The Proposed Action is described first. The descriptions of alternatives 2 and 3 follow and focus on how they differ from the Proposed Action.

In addition to the details presented below, the action alternatives (Alternatives 1, 2A, and 2B) include the Standard Conditions of Approval (COAs) for APDs that the BLM has been requiring for oil and gas wells drilled into federal minerals in the Project Area. These COAs are included as Appendix C.

Alternative 1 — Proposed Action

The Proposed Action is to continue development of CBM and conventional oil/gas resources within the Project Area. It is projected that an additional 39,367 CBM wells and 3,200 conventional oil/gas wells would be developed over the next ten years.

This alternative is a combination of the Companies' proposal and the BLM's RFD Scenario. The BLM used the RFD Scenario's moderate level of development and the Companies' proposal to establish the overall level of development of CBM resources likely for this alternative. The Companies' proposal provided the basis for how the Companies would implement the CBM portion of the alternative (e.g., drilling, completion, operation, and reclamation). The BLM used the RFD Scenario to establish the overall level of additional development of non-CBM resources within the PRB.

The result of combining the Companies' proposal and the RFD Scenario is a Proposed Action that consists of two primary components. The first is the CBM wells and their ancillary facilities. The second component is the non-CBM wells

and their ancillary facilities. Because these two components use different technologies and techniques and involve different levels of disturbance, they are discussed separately.

Coal Bed Methane Development

Under this alternative, the Companies' would drill, complete, and operate 39,367 new CBM wells within the Project Area over a 10-year period (Table 2–1). Including the 12,077 CBM wells already drilled or permitted for drilling in the Project Area, the Companies would drill, complete, and operate 51,444 CBM wells by the end of 2011 (Figure 2–1 and Table 2–2).

The Companies also would construct the ancillary facilities needed to support these wells. The ancillary facilities include access roads; pipelines for gathering gas and produced water; electrical utilities; facilities for measuring and compressing gas; facilities for treating, discharging, disposing of, containing, or injecting produced water; and pipelines for delivering gas to high-pressure transmission pipelines. These transmission pipelines would deliver the gas to market.

The overall life of the Proposed Action, including drilling, production, and reclamation, is expected to be about 20 years. Construction of the 39,367 new wells would begin during 2002. The Companies would drill these wells over a 10-year period (Table 2–1). The productive life of each well is expected to be about 7 years. Accordingly, production from at least some of the 39,367 new wells is expected to last until 2018. Final reclamation of these wells would occur during the two to three years following the end of production. Thus, the Proposed Action would be completed around 2021.

In parts of the Project Area, several coal beds occur together. In these areas, the standard practice presently is to drill a separate well to develop each coal bed. Where possible, the Companies would collocate these wells on the same well pad. Based on this practice of collocation and knowledge of where multiple gas-productive coal beds exist, the BLM and Companies project the 39,367 new wells would be drilled from about 26,000 well pads (Table 2–3). The total number of wells and well pads is based on an 80-acre well spacing pattern overall (eight pads per square mile). Including the pads constructed for wells drilled before 2002, the 51,444 CBM wells would be distributed across almost 35,600 well pads (Table 2–4 and Figure 2–1). The number of wells on a pad would range from one to three.

Under the Proposed Action, the Companies would drill, operate, and maintain wells and construct ancillary facilities in 10 of the 18 sub-watersheds that comprise the Project Area (Table 2–5). However, most of the new wells (63 percent) and facilities would be constructed in two sub-watersheds: the Upper Powder River and Upper Belle Fourche River sub-watersheds. Other sub-watersheds with relatively high numbers of wells and facilities include Clear Creek, Crazy Woman Creek, Upper Tongue River, and Little Powder River.

Overall, implementation of the CBM portion of the Proposed Action could disturb as many as 211,992 surface acres, most of which would be associated with the construction of pipelines, roads, and water handling facilities (Table 2–6).

Compressor stations would account for the smallest amount of the overall surface disturbance. Short-term disturbance would encompass about 3 percent of the Project Area.

Following reclamation of pipelines partial reclamation of other facilities, such as well pads, the Proposed Action's long-term disturbance from CBM development would encompass about 108,800 acres (Table 2–7). The long-term disturbance is a 45 percent reduction from the total short-term disturbance. The roads and water handling facilities would comprise most of the long-term disturbance.

The following sections describe the Proposed Action in detail. Implementation would occur in three primary phases: drilling of wells and construction of production facilities, production and maintenance, and decommissioning and reclamation. Consequently, the detailed description of the Proposed Action is organized by these three primary phases.

Drilling of Wells and Construction of Production Facilities

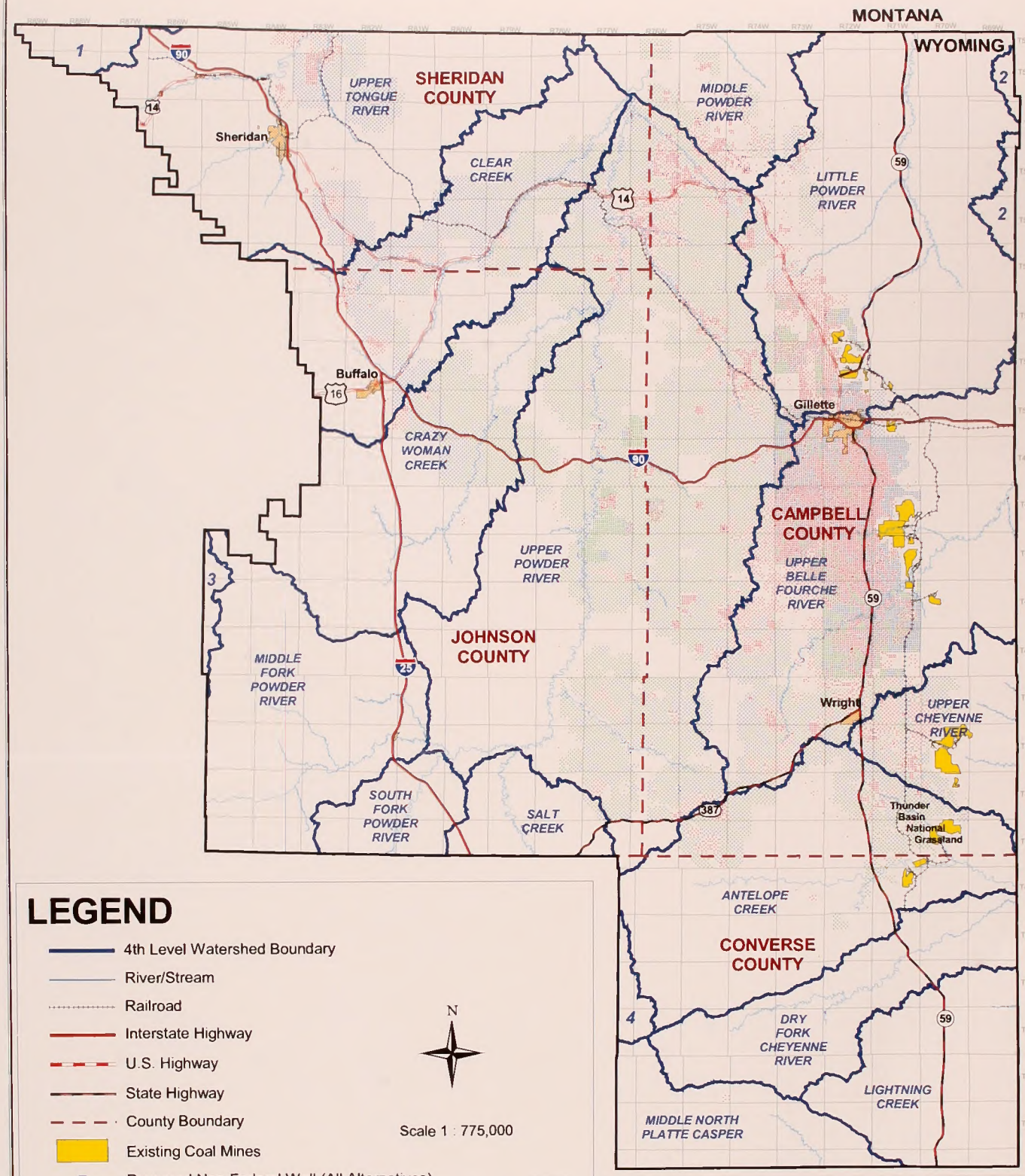
This section describes the overall procedures, techniques, and resources the Companies would use to construct roads, well pads, and ancillary production facilities and to drill, case, and complete the CBM wells.

Well Access Roads

Most roads to well pads (resource roads) would be developed in two steps. Initially, each road would be roughed in as a two-track road. Generally, the BLM requires improved graded and graveled roads to non-CBM operations. However, because the need to travel to the CBM wells is normally very limited, the BLM has waived the blanket requirements for road improvements to minimize surface disturbance. Any need for surfacing or other upgrading would be determined in consultation with the BLM or other landowner based on site-specific conditions. In some cases, roads may require upgrading before drilling the wells. However, if the well is not completed successfully and is plugged, the road would be reclaimed.

Unless work is needed to alleviate concerns about safety, environmental issues, or access difficulties, the Companies would maintain roads used to access well pads in a two-track status. Areas where work may be needed include stream drainage crossings, low water crossings, and rough topography. Gravel may be applied to problem areas. Also, travel on two-track roads would be rescheduled or postponed during the infrequent periods of wet weather when vehicular traffic could cause rutting.

The BLM's experience in more rugged terrain, such as within the Powder River drainage, suggests construction of a more substantial access road to the well pad using cut and fill construction techniques may be necessary about 20 percent of the time within the Project Area. Surface disturbance associated with crowning and ditching (normally required by BLM's general policy on design and construction of oil and gas well access roads) would occur only as required for access roads traversing steeper terrain or rough, broken topography, or in other exceptional site-specific circumstances.



LEGEND

- 4th Level Watershed Boundary
- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary
- Existing Coal Mines
- Proposed Non-Federal Well (All Alternatives)
- Proposed Federal Well (Alternatives 1, 2A, 2B)
- Existing CBM Well

N

Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 2-1 DISTRIBUTION OF EXISTING AND PROPOSED WELLS	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/14/01	ArcView File: C:\1011_v1\data\maps.apr Layout--CBM_Well_Distribution
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13


LEGEND

Table 2–1 Distribution of New Producing CBM Wells by Sub-watershed — Alternative 1

Sub-watershed	Year										Total
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	101	277	277	277	277	277	277	277	277	272	2,589
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	2,785	2,640	2,640	2,514	2,499	2,499	2,012	488	455	435	18,967
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	10	6	7	6	8	0	0	0	0	0	37
Crazy Woman Creek	304	351	351	351	346	346	316	191	186	178	2,920
Clear Creek	263	400	400	400	405	405	405	361	359	355	3,753
Middle Powder River	45	102	102	102	102	102	102	102	102	97	958
Little Powder River	214	229	229	229	235	235	235	149	144	136	2,035
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	250	216	216	208	210	210	177	54	52	51	1,644
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	80	65	65	65	65	65	62	30	21	15	533
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	908	751	751	738	760	760	710	201	178	174	5,931
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0
Total	4,960	5,037	5,038	4,890	4,907	4,899	4,296	1,853	1,774	1,713	39,367

Source: BLM 2001e

Table 2–2 Distribution of All CBM Wells by Sub-watershed — Alternative 1

Sub-watershed	Pre-2002[1]	Year										Total
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	815	101	277	277	277	277	277	277	277	277	272	3,404
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	2,808	2,785	2,640	2,640	2,514	2,499	2,499	2,012	488	455	435	21,775
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	10	6	7	6	8	0	0	0	0	0	37
Crazy Woman Creek	150	304	351	351	351	346	346	316	191	186	178	3,070
Clear Creek	389	263	400	400	400	405	405	405	361	359	355	4,142
Middle Powder River	727	45	102	102	102	102	102	102	102	102	97	1,685
Little Powder River	1,813	214	229	229	229	235	235	235	149	144	136	3,848
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	253	250	216	216	208	210	210	177	54	52	51	1,897
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	454	80	65	65	65	65	65	62	30	21	15	987
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	4,662	908	751	751	738	760	760	710	201	178	174	10,593
Middle North Platte River	6	0	0	0	0	0	0	0	0	0	0	6
Total	12,077	4,960	5,037	5,038	4,890	4,907	4,899	4,296	1,853	1,774	1,713	51,444

Note:

1. The Pre-2002 wells include wells already drilled (some of which are producing) and those projected for completion by 2002 (but not necessarily producing).

Source: BLM 2001e

Table 2–3 Distribution of New Well Pads by Sub-watershed — Alternative 1

Sub-watershed	Year										Total
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	41	111	138	109	93	148	140	132	103	124	1,139
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	1,744	1,806	1,602	1,582	1,613	1,574	1,104	288	340	189	11,842
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	10	6	7	6	8	0	0	0	0	0	37
Crazy Woman Creek	304	319	225	235	217	194	153	103	88	60	1,898
Clear Creek	212	296	276	252	308	255	255	269	233	228	2,584
Middle Powder River	21	50	48	47	48	50	50	51	51	49	465
Little Powder River	137	162	135	142	154	118	149	74	108	86	1,265
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	232	195	192	184	202	169	162	46	44	25	1,451
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	80	65	65	65	65	65	62	30	21	15	533
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	809	627	629	583	586	578	574	114	153	130	4,783
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0
Total	3,590	3,637	3,317	3,205	3,294	3,151	2,649	1,107	1,141	906	25,997

Source: BLM 2001e

Table 2–4 Distribution of All CBM Well Pads by Sub-watershed — Alternative 1

Sub-watershed	Pre-2002	Year									Total
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	396	41	111	138	109	93	148	140	132	103	124	1,535
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	2,253	1,744	1,806	1,602	1,582	1,613	1,574	1,104	288	340	189	14,095
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	10	6	7	6	8	0	0	0	0	0	37
Crazy Woman Creek	63	304	319	225	235	217	194	153	103	88	60	1,961
Clear Creek	229	212	296	276	252	308	255	255	269	233	228	2,813
Middle Powder River	434	21	50	48	47	48	50	50	51	51	49	899
Little Powder River	1,301	137	162	135	142	154	118	149	74	108	86	2,566
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	251	232	195	192	184	202	169	162	46	44	25	1,702
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	389	80	65	65	65	65	65	62	30	21	15	922
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	4,270	809	627	629	583	586	578	574	114	153	130	9,053
Middle North Platte River	6	0	0	0	0	0	0	0	0	0	0	6
Total	9,592	3,590	3,637	3,317	3,205	3,294	3,151	2,649	1,107	1,141	906	35,589

Source: BLM 2001e

Table 2–5 Summary of New CBM Facilities Comprising Alternative 1

Sub-watershed	Well Pads	Roads		Poly Pipeline		Steel Pipeline	Electrical Line	Recip Compressors[1]		Booster Compressors[2]	
		Improved (miles)	Two-track (miles)	2–3-inch (miles)	12-inch (miles)	12-inch (miles)	Overhead (miles)	(units)	(horsepower)	(units)	(horsepower)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	1,139	307	430	571	215	70	215	9	14,850	31	10,850
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	11,842	2,151	3,002	3,996	1,501	521	1,501	192	316,800	691	241,850
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	37	43	72	96	36	7	36	1	1,650	4	1,400
Crazy Woman Creek	1,898	468	680	905	340	108	340	21	34,650	72	25,200
Clear Creek	2,584	473	748	995	374	76	374	14	23,100	49	17,150
Middle Powder River	465	141	155	207	78	39	78	3	4,950	9	3,150
Little Powder River	1,265	496	872	1,161	436	45	436	9	14,850	30	10,500
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	1,451	1,567	3,038	4,041	1,519	35	1,519	11	18,150	40	14,000
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	533	127	137	182	69	37	69	5	8,250	16	5,600
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	4,783	884	1,483	1,973	743	98	743	33	54,450	118	41,300
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0
Total	25,997	6,657	10,619	14,127	5,311	1,036	5,311	298	491,700	1,060	371,000

Notes:

1. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
2. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.

Source: BLM 2001e

Table 2–6 Summary of Estimated Short-term CBM Disturbance Associated with Alternative 1

Sub-watershed	Well Pads (acres)	CMFs (acres)	Roads		Poly Pipeline		Water Handling Facilities[1] (acres)	Compressor Discharge Pipelines		Power Line	Compressor Stations		Total (acres)
			Improved (acres)	Two-track (acres)	2–3-inch (acres)	12-inch (acres)		Recip.[2] (acres)	Booster[3] (acres)	Overhead (acres)	Recip. (acres)	Booster (acres)	
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	632	59	708	2,083	2,077	782	3,120	248	606	782	25	10	11,132
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	4,978	435	4,973	14,556	14,529	5,459	12,423	1,788	4,527	5,459	415	166	69,708
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	11	1	78	351	350	132	34	24	61	132	5	2	1,181
Crazy Woman Creek	774	67	1,030	3,299	3,289	1,235	2,102	291	1,014	1,235	50	20	14,406
Clear Creek	1,009	86	936	3,628	3,620	1,360	4,391	320	605	1,360	35	14	17,364
Middle Powder River	238	22	400	754	752	283	786	206	267	283	15	6	4,012
Little Powder River	534	47	818	4,230	4,222	1,586	1,669	218	323	1,586	20	8	15,261
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	474	38	2,076	14,732	14,695	5,524	1,504	127	298	5,524	25	10	45,027
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	160	12	364	663	662	249	488	145	303	249	10	4	3,309
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	1,664	136	1,582	7,190	7,176	2,702	6,168	315	873	2,702	60	24	30,592
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	10,474	903	12,965	51,486	51,372	19,312	32,685	3,682	8,877	19,312	660	264	211,992

Notes:

1. Disturbance includes the areal extent of direct discharge facilities, containment reservoirs, land application facilities, and injection wells. The ratios of water handling facilities applied to each sub-watershed are shown on Table 2–9.
2. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
3. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.

Source: BLM 2001e

Table 2–7 Summary of Estimated Long-term CBM Disturbance Associated with Alternative 1

Sub-watershed	Well Pads (acres)	CMFs (acres)	Roads: Improved (acres)	Roads: Two-track (acres)	Poly Pipeline: 2–3-inch (acres)	Poly Pipeline: 12-inch (acres)	Water Handling Facilities[1] (acres)	Compressor Discharge Pipelines: Recip.[2] (acres)	Compressor Discharge Pipelines: Booster[3] (acres)	Power Line: Overhead (acres)	Compressor Stations: Recip. (acres)	Compressor Stations: Booster (acres)	Total (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	259	24	708	2,083	0	0	3,120	0	0	261	25	10	6,490
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	1,897	174	4,973	14,556	0	0	12,423	0	0	1,820	415	166	36,424
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	4	0	78	351	0	0	34	0	0	44	5	2	518
Crazy Woman Creek	292	27	1,030	3,299	0	0	2,102	0	0	412	50	20	7,232
Clear Creek	375	35	936	3,628	0	0	4,391	0	0	453	35	14	9,867
Middle Powder River	96	9	400	754	0	0	786	0	0	94	15	6	2,160
Little Powder River	204	19	818	4,230	0	0	1,669	0	0	529	20	8	7,497
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	164	15	2,076	14,732	0	0	1,504	0	0	1,841	25	10	20,367
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	54	5	364	663	0	0	488	0	0	83	10	4	1,671
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	593	55	1,582	7,190	0	0	6,168	0	0	901	60	24	16,573
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3,938	363	12,965	51,486	0	0	32,685	0	0	6,438	660	264	108,799

Notes:

1. Disturbance includes the areal extent of direct discharge facilities, containment reservoirs, land application facilities, and injection wells. The ratios of water handling facilities applied to each sub-watershed are shown on Table 2–9.
2. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
3. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.

Source: BLM 2001e

In general, the Companies would reclaim access roads not needed for production (e.g., access roads to plugged and reclaimed wells) as soon as practical. However, with the surface owner's concurrence the Companies could leave in place roads that have value for ranching or agricultural uses.

Well Pads

The minimum area required for a well pad would vary by company. Initially, the sizes of well pads would range from a minimum of 0.3 acre (100 feet by 150 feet) to a maximum of about 0.7 acre (175 feet by 175 feet). Upon the successful completion of a well, portions of the well pad not needed for production equipment and activities would be reclaimed. Over the long-term, the size of well pads would be reduced to a minimum of about 0.1 acre (75 feet by 75 feet) for pads with one well to about 0.3 acre (115 feet by 115 feet) for pads with three wells.

Construction at a well pad would be minimal. At level well pads, little clearing of vegetation or soil would occur. At each drill site, a temporary mud pit approximately 6 feet deep, 10 feet wide, and up to 30 feet long, would be excavated, used during drilling and completion operations, and then reclaimed.

In areas where the surface of the ground is too steep to allow a drill rig to set up over native ground, the Companies would use limited cut and fill construction techniques to level a work area. Use of cut and fill construction techniques for well sites may be necessary an estimated 20 percent of the time. Areas disturbed, but not needed for production, would be reclaimed as soon as practical after the conclusion of drilling.

Drilling

Upon completion of the access road and preparation of the well pad (if needed), a mobile drilling rig would be driven to the site and erected. Typically, the Companies use a truck-mounted water well type of drilling rig to drill CBM wells in the Project Area. Additional equipment and materials needed for drilling operations, including water, would be trucked to the site. On average, drilling would require about 26,000 gallons (0.08 acre-feet) of water per well for preparing cement, stimulating the well, controlling dust, and drilling (non-toxic drilling mud is required to handle certain down-hole conditions). Drilling mud usually is native mud and bentonite. As hole conditions dictate, small amounts of polymer additives and/or potassium chloride salts may be added for cleaning the hole and stabilizing clay.

The WOGCC and BLM currently require surface casing of 60 feet or 10 percent of the total depth of the well be set with cement returns to the surface. The drilling of individual wells proceeds as follows. A well is drilled to a depth of 350 feet to 1,500 feet or deeper to the top of a coal zone. The well control system is designed to meet the conditions likely to be encountered in the hole and would be in conformance with the BLM and State of Wyoming's requirements. At a minimum, the WOGCC and BLM require a diverter after surface casing is set.

Drilling and completion operations for a CBM well normally involves about 7 to 15, including personnel for logging and cementing activities. Each well would be

drilled within one to three days. When the target coal is reached, well production casing would be placed and cemented. Placement of production casing (casing the hole) would include the insertion of a steel pipe into the drill hole from the bottom of the hole to the surface. Casing would be set into the hole one joint at a time and would be threaded at one end with a collar located at the other end, to connect each joint.

The casing would be cemented into place by pumping a slurry of dry cement and water into the casing head, down through the casing string to the bottom, and then up through the spacing between the casing and the well (annulus). A plug and water flush then would be pumped to the bottom of the well to remove any residual cement from the inside walls of the casing. Sufficient cement would be pumped into the annulus to fill the space where it would be allowed to harden.

A cement bond log would be run on the well to ensure no voids remain in the annulus. Cementing the annulus around the casing pipe restores the original isolation of formations by creating a barrier to the vertical migration of fluids and gas between rock formations within the borehole. It also protects the well by preventing formation pressures from damaging the casing and retards corrosion by minimizing contact between the casing and corrosive formation waters.

Once the cement sets up or hardens behind the casing, the coal zone would be drilled using either air or water. The size of the hole in the coal below the casing is enlarged using an upreamer bit that may extend out to an 18-inch diameter or more. The well would be completed "open hole" in the coal without placing any more steel casing in the hole.

After the coal zone is drilled, the open hole may be flushed with clean chlorinated water (from approved and properly permitted facilities) to remove the coal fines from the hole. Steel tubing then would be placed inside the casing and in the open hole. A submersible electric pump would be placed on the bottom end of the tubing to pump water from the coal. The size and capacity of the submersible pump would depend on the coal's thickness and the rate of production expected from the well. Most pumps are rated at 10 to 20 gallons per minute (gpm). The water pressure in the coal zone must be reduced before gas (methane) will flow to the open hole. The water would be pumped up the tubing to the surface where, generally, it would be gathered in a pipeline for disposal. When the gas is released from the coal, it flows up the space between the tubing and the steel casing to the gas-gathering system and compressors at the surface.

Upon completion of the well, all disturbed areas not needed for production facilities would be restored. The mud pit would be dried and backfilled. Seeding of these areas takes place as soon as practicable.

Wells determined to be unsuccessful would be plugged, abandoned, and then reclaimed. Abandonment would follow the procedures set forth by the WOGCC and/or the BLM. Reclamation would be completed according to the BLM's regulations and/or the surface owner agreement.

Well Production Facilities

After well productivity is established, a small area of about 5 to 6 feet square would be leveled and a weatherproof covering or box would be placed over the wellhead. Usually, a metal fence or rail would be placed immediately around the box and electrical panel to protect them from livestock. Meters to measure pressure and rates of water production may be placed in the box. There would be no pump jacks at the wellhead site; however, injection facilities, including some treatment facilities, likely would be collocated at CBM wells. The power lines for the submersible water pump would be laid in trenches, usually with water pipelines, and would not be placed on poles. This would minimize the surface disturbance and visual impact of the Proposed Action.

Pipelines

Three types of pipelines would be constructed as part of the Proposed Action. They are gas-gathering pipelines, produced water-gathering pipelines, and high-pressure gas delivery pipelines. The gas-gathering and produced-water gathering pipelines would conduct gas and produced water from the wells to compressor facilities and produced-water discharge or disposal points, respectively. The high-pressure gas pipelines would connect compressor facilities to the existing and proposed transmission pipelines. Rights-of-way for the pipelines would vary from 20 to 50 feet for polyethylene pipeline and 100 feet for steel pipelines.

All three types of pipelines would be installed along access roads to minimize disturbance, except where topography or concerns of surface owners dictate otherwise. Gas-gathering pipelines and produced water-gathering pipelines would be placed together in the same trench/ditch. High-pressure pipelines would be installed in a separate ditch. Gas and produced water-gathering pipelines would be constructed of polyethylene pipe with an outside diameter of 2 to 12 inches. The high-pressure pipelines would be constructed of steel pipe with an outside diameter of 12 to 16 inches.

Usually, the gas-gathering pipeline would be laid in a ditch constructed by a small mechanical belt-ditching machine. This method of construction would involve very little surface disturbance and the clearing of little or no vegetation. The construction right-of-way for gas-gathering pipelines would range from 20 to 50 feet. The actual width of the trench would range from 18 to 36 inches.

Generally, the construction of pipelines would occur in a planned sequence of operations and along roads where possible. Where feasible, trees would be avoided. Brush and woody vegetation would be left in-place and driven over as necessary (crushed but potentially capable of redeveloping a vegetative canopy). If necessary, the path would be cleared of trees and heavy brush by brush beating or lightly blading the surface. Soils would be left undisturbed over much of the construction work area, although some compaction may occur. Pipeline crossings of streams would be conducted according to the requirements of 404 permitting. Overall, the crossings would be constructed to minimize the length and the locations of the crossings would be returned to approximate original configurations. Reclamation would begin immediately after burying the pipeline.

Facilities for the Gathering and Disposing of Produced Water

Polyethylene pipe 2 to 3 inches in diameter would be connected to the tubing in the well and brought underground in a trench to a point of discharge into a natural drainage or disposal containment. The current average rate of water production per well, according to the WOGCC, is about 10 gpm (Likwartz 2001). This individual well rate may rise as deeper, thicker coals are produced. Higher rates are expected in the Powder River sub-watershed where the Big George Coal reaches a maximum thickness of about 200 feet. The Powder River drainage basin is expected to have nearly half of the wells drilled under this alternative. The Companies are aware of this issue and have already initiated watershed studies for dealing with water issues in three of the major tributaries of the Powder River where drilling is occurring or is about to occur. Historically, based on production information available on the WOGCC website, the water production rate from a new area where the water pressure is being reduced before gas production drops to one-half the initial rate after the first year's production. The maximum production rate over the entire Project Area is expected to occur in 2006 with about 381,000 acre-feet of water per year (Table 2–8).

The method of handling produced water would vary as the water quality, water volumes, and surface owner desires change. Potential water handling methods include direct surface discharge, treatment of produced water followed by direct surface discharge, containment of produced water, and injection of produced water through disposal wells (Table 2–9). Presently, the primary method of disposal is to bring the water via underground pipe to a surface discharge location mutually selected by the operator and the surface owner or lessee. Discharges are permitted by the WDEQ after the issuance of a National Pollutant Discharge Elimination System (NPDES) permit. The following sections describe the assumptions developed for the analysis of water handling

Surface Discharge Analysis Assumptions

Produced water from CBM wells would be gathered for discharge at outfalls. Surface discharge facilities of varying sizes would be constructed; however, for the purpose of this analysis an average facility, described below, was analyzed. On average, five wells would be discharged together at the same outfall. Outfalls may feed into small stock reservoirs or other treatment facilities before the outflows reach surface drainages. CBM produced water that is discharged to the surface may be suitable for irrigation use and may be diverted for that purpose. On average, all facilities associated with untreated or passively treated surface discharge for up to 20 CBM wells (estimated to be four "bubbler" outfalls, a stock pond, and an armored stream channel for the purpose of this analysis) would encompass an estimated 6 acres or approximately 0.3 acres per well. On average, all facilities associated with actively treated surface discharge for CBM wells also would encompass approximately 0.3 acres per well.

Infiltration Impoundments Analysis Assumptions

Produced water from CBM wells would be gathered for discharge into infiltration impoundments, where infiltration is selected as the water handling option because of concerns about the magnitude of increased surface flows or produced water quality. Infiltration impoundments of varying sizes would be constructed; however, for the purpose of this analysis an average impoundment encompassing

Table 2–8 Projected Amount of Water Produced from CBM Wells Under Alternatives 1, 2A, and 2B

	Water Produced (in acre-feet)[1]																
Sub-watershed	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	35,002	44,061	47,659	48,428	49,455	52,606	47,671	52,142	50,520	51,044	48,020	46,011	43,446	36,629	24,070	19,546	696,310
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	107,118	132,947	148,617	157,336	162,534	160,025	154,501	137,894	124,112	108,585	92,756	74,276	49,881	24,801	13,433	3,683	1,652,499
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	60	107	119	118	129	126	123	62	40	26	16	0	0	0	0	0	926
Crazy Woman Creek	14,329	21,310	26,241	29,120	31,185	32,578	32,268	28,740	23,832	20,861	17,116	13,687	10,655	6,742	4,403	2,374	315,441
Clear Creek	24,467	39,632	49,641	58,210	66,116	70,983	70,323	68,746	65,343	61,663	54,485	46,526	38,472	30,578	19,586	10,601	775,372
Middle Powder River	11,133	10,618	9,662	8,209	7,266	7,204	6,810	6,902	6,902	6,806	4,850	3,222	1,924	954	321	156	92,939
Little Powder River	14,650	13,873	13,610	13,250	11,949	6,931	4,440	4,471	4,395	4,098	3,396	3,212	2,293	2,050	1,349	658	104,625
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	6,753	7,586	8,775	9,241	9,552	9,899	9,543	9,141	8,473	7,800	7,175	6,277	5,072	3,921	2,665	1,973	113,846
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	3,665	3,569	3,366	3,158	2,983	2,587	2,444	2,246	2,031	1,730	1,852	1,527	1,412	1,030	251	303	34,154
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	47,192	44,376	42,397	40,996	39,827	35,340	29,670	28,398	26,866	25,991	22,194	18,758	15,358	7,512	6,536	2,794	434,205
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	264,369	318,079	350,087	368,066	380,996	378,279	357,793	338,742	312,514	290,615	251,860	213,496	168,513	114,217	72,614	42,088	4,220,317

Note:

1. Volumes shown include produced water from pre-2002 wells as well as the new CBM wells.

Source: Applied Hydrology and Associates 2001c

Table 2–9 Assumed Water Handling Methods for CBM Wells Under Alternatives 1 and 3

	Water Handling Method[1,2,3]						
	NPDES-permitted Discharge						
Sub-watershed	Untreated Discharge (percent)	Passive Treatment (percent)	Active Treatment (percent)	Infiltration Impoundment (percent)	Containment Impoundment (percent)	LAD (percent)	Injection (percent)
Upper Tongue River	0	35	0	45	10	0	10
Upper Powder River	75	0	0	15	5	0	5
Salt Creek	55	0	0	35	5	0	5
Crazy Woman Creek	70	0	0	5	5	15	5
Clear Creek	25	10	0	40	5	10	10
Middle Powder River	60	5	0	10	10	10	5
Little Powder River	65	0	0	10	10	10	5
Antelope Creek	55	0	0	35	5	0	5
Upper Cheyenne River	55	0	0	35	5	0	5
Upper Belle Fourche River	45	0	0	40	5	0	10

Notes:

1. The percentages shown represent the distribution of water handling methods assumed for the analysis, not the amount of water that actually reaches the river.
2. Handling Methods:
   NPDES-permitted Discharge – includes methods of handling the produced water that require an NPDES permit.
   Untreated discharge – water that is discharged onto the surface of the ground or into drainages tributary to perennial waters of the state without any treatment.
   Passive treatment – water that is amended through passive methods to meet standards before discharge. An example of this method is passing the water over scoria to remove iron.
   Active treatment – water that is amended through active methods to meet standards before discharge. An example of this method is passing the water through a reverse osmosis system.
   Infiltration impoundment – water contained in upland and bottomland impoundments designed for maximum infiltration and groundwater recharge.
   Containment impoundment – includes upland impoundments, both lined and unlined, with minimal infiltration and no direct surface discharge or lateral subsurface movement of water and down-gradient expression in seeps or springs. These impoundments would be permitted by either the WOGCC or DEQ, depending on which agency has jurisdiction for the specific impoundment.
   LAD = land application disposal. Typically, land application is achieved by spraying produced water through agricultural irrigation equipment and high-pressure atomizers.
   Injection – represents that water that is injected into disposal wells.
3. The above percentages are not upper thresholds that can or would be enforced. They are merely a disclosure of effects of one of many various ways water may be handled to meet the Montana/Wyoming agreement of water quality levels at the state line.

6 acres and having a capacity of approximately 48 acre-feet was analyzed. Also, for the purpose of this analysis, CBM wells are projected to produce water at the rate of 9.5 gpm during their productive life.

Shallow impoundments having a dam height, on average, of 13 feet would be constructed in bottomland and upland areas in a manner that allows infiltration and prevents surface discharge. In some cases, the bottom surface of an impoundment area may contain key trench-type excavations or closely spaced boreholes to enhance infiltration. Evaporation would be enhanced using atomizers placed on towers situated on floating islands, with spray from these units directed above the water surface only.

Upland Areas – For the purpose of this analysis, each impoundment constructed in an upland area, on average, would encompass an estimated 6 acres (48 acre-feet capacity), containing all water produced over the life of the CBM wells undergoing infiltration, and disturbing an estimated 1.6 acres per well undergoing infiltration. On average, each impoundment would contain all of the produced water from five CBM wells. In most cases, impoundments would not be con-

structed as flow-through structures. All surface and overland flows likely would be diverted away from the impoundments. Where surface flows are not diverted, impoundments would be designed to hold, pass through, or flush contents and surface flows, based on a design event. Livestock and wildlife would not be fenced out. The impoundments would not be netted. On average, enhanced evaporation would reduce the water impounded by an estimated 4 feet per year. On average, infiltration would reduce the water impounded by an estimated 8 feet per year (AHA and Greystone 2001).

Bottomland Areas - Each impoundment constructed in a bottomland area, on average, would encompass an estimated 6 acres (48 acre-feet capacity), containing all water produced over the life of the CBM wells undergoing infiltration, and disturbing an estimated 1.6 acres per well undergoing infiltration. On average, each impoundment would contain all of the produced water from five CBM wells. If enhanced evaporation and infiltration methods are successful, each impoundment could contain all the produced water from up to 10 wells. Impoundments likely would be constructed within or near drainages, floodplains, and gravelly terraces, and may be constructed as flow-through structures. All surface and overland flows may be diverted away from the impoundments. Where surface flows are not diverted, impoundments would be designed to hold, pass through, or flush contents and surface flows, based on a design event. Livestock and wildlife would not be fenced out. The impoundments would not be netted. On average, enhanced evaporation would reduce the water impounded by an estimated 4 feet per year. On average, infiltration would reduce the water impounded by an estimated 8 feet per year (AHA and Greystone 2001).

Containment Analysis Assumptions

Produced water would be gathered for discharge into containment impoundments, where containment (no discharge to surface drainages and minimal infiltration) is selected as the water handling option because of poor quality of the CBM produced water. Large containment reservoirs of varying sizes would be constructed; however, for the purpose of this analysis an average impoundment encompassing 100 acres and having a capacity of approximately 2,000 acre-feet was analyzed. These reservoirs would be constructed in upland areas, away from drainages, floodplains, and gravelly terraces, and would not be constructed as flow-through impoundments. All surface and overland flows would be diverted away from the reservoirs. Livestock and wildlife may be fenced out if water quality does not meet recommendations for these uses. The reservoirs would not be netted, as that would not be feasible, given the size of the impoundments.

Each of these reservoirs would contain all of the produced water from 60 wells, over the life of the wells. For the purpose of this analysis, CBM wells are projected to product water at the rate of 9.5 gpm, on average, over their productive life. Each reservoir would encompass a surface area of about 100 acres, would be about 8 feet deep at the end of 3 years, and would be 20 feet deep at the end of 10 years (design capacity). The total disturbed area for each reservoir would be about 140 acres, or about 2.3 acres per well. The dam would be 25 feet high, to allow for freeboard of 5 feet. Embankment slopes would be 1:3 and would include a 12 feet wide flat area along the top of the embankment to allow for heavy

equipment. Generally, about one half of the reservoir would be excavated below the natural ground level.

Atomizers would be located on towers situated on floating islands in the central portions of the reservoir. Spray from these units would be directed above the water surface only so that the land surface near the reservoir would be unaffected. On average, enhanced evaporation would reduce the water impounded by an estimated 4 feet per year. On average, infiltration would reduce the water impounded by an estimated 0.75 feet per year (10 percent).

Land Application Disposal Analysis Assumptions

All water produced over the life of 40 wells would be spread on the land surface of a land application disposal (LAD) site using mobile atomizers or irrigation equipment. All water would be contained within the LAD site. An estimated 100 percent of the water would be used consumptively. Infiltration and channelized surface runoff would be negligible. For the purpose of this analysis, each LAD site would disturb an estimated 64 acres or an estimated 1.6 acres per well.

Disposal likely would be accomplished using a disposal-rest rotation cycle consisting of disposal, soil amendment, rest, disposal... until the limitations of repeated soil amendments are reached, and a portion of the site would be reclaimed.

The LAD facilities would be associated with an impoundment. During periods when the water could not be applied (e.g., winter or equipment malfunction), the water would be stored in the impoundment. The impoundments are addressed in the previous sections on surface discharge, infiltration and containment.

Injection Analysis Assumptions

Produced water from 6 to 10 CBM wells would be gathered for injection into the Fort Union Formation or a lower injection zone. For the purpose of this analysis, on average, injection well facilities, including water transfer facilities, flowlines, and roads serving 8 CBM wells would disturb an estimated 12 acres, or approximately 1.5 acres per well.

Central Metering Facilities

Typically, natural gas produced from each well is individually measured and mechanically or electronically recorded at a central point or central metering facility (CMF). Gas-gathering pipelines for an average of ten wells would be tied together in a CMF, where metering for all the connected wells would occur. At the CMF, gas would be commingled into the gas-gathering system, which would transport it to the compressor station. An improved road would be constructed to each CMF, which would disturb an area no wider than 50 feet. Construction of each CMF would disturb about 0.2 acre (100 feet by 100 feet) for the short term. This disturbance would be reduced to about 0.1 acre (50 feet by 80 feet) for the long term.

The wells connected to a CMF may produce water for some time (occasionally more than a year) before natural gas (methane) is produced. The water produced would be disposed of using methods that meet standards of the WDEQ, BLM,

WOGCC, and WSEO. Small amounts of gas may be produced in the initial stages of de-pressuring the coal bed. This gas may be vented until sufficient volumes are produced to run a first stage compression system near the CMF. Any venting would be done according to the BLM's Notice to Lessees 4A (Royalty or Compensation for Oil and Gas Lost), and Onshore Order No. 5 (Measurement of Gas) and by permission of the WOGCC and BLM in Sundry Notices. Immediately upon reaching a volume capable of sustaining compression operations, the wells producing gas would be shut in until the necessary pipeline connections are made.

Natural gas (methane) production is expected to reach a maximum rate for the entire Project Area of almost 3.6 billion cubic feet per day (bcf) in 2006 and 2007. Current total recoverable reserve estimates range from 13 to 25 trillion cubic feet of gas (BLM 2001f). Other estimates suggest total recoverable reserves range from 12 to 37 trillion cubic feet of gas (Crockett et al. 2001).

Electrical Power Utilities

Although the Companies would use gas-fired compressors, other equipment, such as pumps, would be electric. In addition, natural gas-fired and diesel engine-powered generators may be used temporarily at individual wells until electrical distribution lines are constructed.

Based on projected power demands, it is anticipated that the Companies would require 0.5 megawatt (MW) per day to transport 3 bcf of natural gas per day using gas-fired compression. Based on this power demand, the maximum power requirement would be 0.6 MW per day.

Under this alternative, three-phase 24.9-kilovolt (kV) distribution lines would connect wells and compressor facilities with the existing transmission and distribution system within the Project Area. Electricity would be routed to compressor stations and CMFs aboveground on poles generally located along the access roads or on additional rights-of-way (30 feet wide) across open land. Between the CMFs and wells, the secondary electric service power lines (480 volt) would be buried in the same trenches with the gas- and produced water-gathering pipelines. The installation and power would be provided by the utility company providing these services. Construction of the power lines would follow access road development and coincide with the completion of well drilling. The power lines would be designed and constructed according to the Avian Power Line Interaction Committee's (1996) guidclines for the prevention of electrocution of raptors.

The aboveground power lines would be constructed using tracked and wheeled equipment. Holes for the poles would be located so as to not disturb existing sensitive vegetation and would be excavated to a depth of 6 to 8 feet. Poles and other structural components would be transported to the construction site where they would be assembled and then erected by a boom truck.

Pole locations could be moved if topography and/or impacts to cultural, vegetative, or wildlife resources are identified at the site of the structure. In areas of thick vegetation and/or where vegetation may impede the performance of the active line, vegetation would be cleared, typically with hand-held equipment.

All aboveground electric lines typically would be installed on 35-foot tall poles. Poles would be required approximately every 300 feet. Approximately 5,311 miles of aboveground power lines would be installed in the Project Area (Table 2–5). The short-term surface disturbance for these lines would be 19,312 acres (Table 2–6). The long-term surface disturbance for the power lines would be 6,438 acres (Table 2–7).

Gas-Delivery System

The gas-delivery system consists of components that would deliver gas produced from the wells (Table 2–10) to the high-pressure transmission pipelines through which the gas would be transported to market. These components include compressor stations and pipelines. This section describes these primary components of this gas-delivery system.

The Companies would construct two types of compressor stations. They are central reciprocating and booster stations. Produced natural gas under pressure from the wellhead would move through the low-pressure gas-gathering system to a booster compressor station. Typical gathering line pressure is less than 50 pounds per square inch (psi). At booster stations, low (350) horsepower (HP) natural gas or electric-powered boosters or blowers would enhance the flow of gas through certain pipelines. As shown on Table 2–11, the Companies expect to construct almost 1,060 new booster compressors. These compressors would be distributed among as many as 186 stations (Table 2–12).

Gas from the booster compressor stations would flow through medium pressure pipelines (50 to 125 psi) to the central reciprocating compressor stations. At these stations, high horsepower (1,650 HP) compressors would increase the pressure of natural gas to an estimated 700 to 1,450 psi to facilitate transmission of the natural gas to high-pressure transmission pipelines. As shown on Table 2–13, the Companies expect to construct almost 298 new reciprocating compressors. These units would be distributed among as many as 63 new stations (Table 2–14).

The compressor sites would be constructed in steps. After obtaining all necessary permits, an access road would be constructed from an existing road to the site. Vegetation would be cleared and topsoil would be stripped and stockpiled. An area of about 2 acres (for booster stations) or 5 acres (for reciprocating stations) would be graded using standard cut-and-fill construction techniques and machinery (bulldozer and/or grader). Concurrent with construction of the compressors, gas pipelines would be built to the site. Also, clear lamp lights (250 watts each) would be installed to light each compressor facility. Each light would be mounted on a pole or building and directed downward to illuminate key areas within the facility while minimizing the amount of light projected outside the facility.

Table 2–10 Projected Amount of Natural Gas Produced from CBM Wells Under Alternative 1

Sub-watershed	Total Cubic Feet of Methane Produced per Day by Year (in mmcf)									
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Little Bighorn River	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	22	36	56	72	84	89	91	92	92	92
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0
Upper Powder River	1,078	1,705	2,056	2,284	2,319	2,301	2,225	1,905	1,317	819
South Fork Powder River	0	0	0	0	0	0	0	0	0	0
Salt Creek	7	11	13	15	15	14	14	12	8	4
Crazy Woman Creek	96	157	196	224	233	234	230	206	160	120
Clear Creek	56	88	115	135	147	152	155	154	147	141
Middle Powder River	8	12	18	22	26	27	27	27	27	27
Little Powder River	56	82	95	103	106	107	108	105	92	81
Little Missouri River	0	0	0	0	0	0	0	0	0	0
Antelope Creek	80	120	137	147	147	145	141	123	91	63
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	30	45	51	55	55	56	56	55	48	42
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	280	398	440	460	456	453	448	407	314	231
Middle North Platte River	0	0	0	0	0	0	0	0	0	0
Total	1,713	2,654	3,177	3,517	3,588	3,578	3,495	3,086	2,296	1,620

Source: Jones 2001

Table 2–11 Distribution of New Booster Compressor Units by Year and Sub-watershed — Alternative 1

	Year							
Sub-watershed	2002	2003	2004	2005	2006	2007	2008	Total
Little Bighorn River								
Upper Tongue River	3	6	8	6	5	2	1	31
Middle Fork Powder River								
North Fork Powder River								
Upper Powder River	195	250	141	91	14			691
South Fork Powder River								
Salt Creek	1	2	1					4
Crazy Woman Creek	17	24	16	11	4			72
Clear Creek	10	13	11	8	4	2	1	49
Middle Powder River	2	1	3	1	2			9
Little Powder River	9	10	5	4	1		1	30
Little Missouri River								
Antelope Creek	14	15	7	4				40
Dry Fork Cheyenne River								
Upper Cheyenne River	6	5	3	1	1			16
Lightning Creek								
Upper Belle Fourche River	47	47	17	7				118
Middle North Platte River								
Total	304	373	212	133	31	4	3	1,060

Source: BLM 2001e

Table 2–12 Distribution of Booster Compressors by Size of Station and Sub-watershed — Alternative 1

	Booster Stations						
Sub-watershed	1-Unit	2-Unit	3-Unit	4-Unit	5-Unit	6-Unit	Total
Little Bighorn River							
Upper Tongue River			1	1		4	6
Middle Fork Powder River							
North Fork Powder River							
Upper Powder River			1	1		114	116
South Fork Powder River							
Salt Creek	1		1				2
Crazy Woman Creek						12	12
Clear Creek			2			7	9
Middle Powder River	1	1	2				4
Little Powder River			2			4	6
Little Missouri River							
Antelope Creek		1		1		6	8
Dry Fork Cheyenne River							
Upper Cheyenne River				1		2	3
Lightning Creek							
Upper Belle Fourche River				1		19	20
Middle North Platte River							
Total	2	2	9	5	0	168	186

Source: BLM 2001e

Table 2–13 Distribution of New Reciprocating Compressors by Year and Sub-watershed — Alternative 1

	Year							
Sub-watershed	2002	2003	2004	2005	2006	2007	2008	Total
Little Bighorn River								
Upper Tongue River	1	2	2	1	2		1	9
Middle Fork Powder River								
North Fork Powder River								
Upper Powder River	54	70	39	25	4			192
South Fork Powder River								
Salt Creek		1						1
Crazy Woman Creek	5	7	4	3	1	1		21
Clear Creek	3	3	3	3	1		1	14
Middle Powder River		1		1			1	3
Little Powder River	3	3	1	1			1	9
Little Missouri River								
Antelope Creek	3	5	2	1				11
Dry Fork Cheyenne River								
Upper Cheyenne River	2	1	1	1				5
Lightning Creek								
Upper Belle Fourche River	13	13	4	3				33
Middle North Platte River								
Total	84	106	56	39	8	1	4	298

Source: BLM 2001e

Table 2–14 Distribution of Recipricating Compressors by Size of Station and Sub-watershed — Alternative 1

	Reciprocating Stations						
Sub-watershed	1-Unit	2-Unit	3-Unit	4-Unit	5-Unit	6-Unit	Total
Little Bighorn River							
Upper Tongue River			1			1	2
Middle Fork Powder River							
North Fork Powder River							
Upper Powder River			6			29	35
South Fork Powder River							
Salt Creek	1						1
Crazy Woman Creek			3			2	5
Clear Creek		1	2			1	4
Middle Powder River			1				1
Little Powder River			3				3
Little Missouri River							
Antelope Creek		1	1			2	4
Dry Fork Cheyenne River							
Upper Cheyenne River		1	1				2
Lightning Creek							
Upper Belle Fourche River			1			5	6
Middle North Platte River							
Total	1	3	19	0	0	40	63

Source: BLM 2001e

Presently, the Companies propose to use natural gas fired compressors at all locations. As development of the Project Area matures, the use of natural gas-fired compressors may diminish and selected units may be constructed with electric-powered compressors. Because the likelihood and extent of this replacement are unknown, the impact analysis documented for Alternative 1 in this EIS assumed all compressors would be fired by natural gas. All compression internal combustion engines, any dehydration units, and any other emission sources must be permitted with the WDEQ's Air Quality Division.

Glycol dehydration units also would be installed at each reciprocating compressor site. The dehydration units would be used to reduce the water in the gas stream to acceptable levels for commercial transportation. The units would have a design flow rate that would accommodate the compression capacity of that station.

High-pressure gas delivery pipelines connecting reciprocating compressor stations with existing and new transmission pipelines would be located along existing roads wherever possible. Disturbance related to these delivery lines is expected to be confined to areas not wider than 100 feet, located within rights-of-way already established, wherever possible.

A variety of high-pressure gas pipelines currently serves the Powder River Basin (Table 2–15). Separately and in combination, these high-pressure systems deliver gas into other high-pressure pipeline systems that are part of the U.S.' natural gas grid. These downstream pipelines are classified as "interstate pipelines". The interstate pipeline companies currently taking gas away from the Powder River Basin are Williston Basin Interstate, Wyoming Interstate Company, Ltd., KM Interstate Pipeline Company, and Colorado Interstate Gas Company.

Table 2–15 Summary of High-pressure Pipelines Currently Operating in the Powder River Basin

Pipeline	Capacity (thousand cubic feet per day)
Fort Union Gas Gathering Company, L.L.P	634,000
Thunder Creek Gas Gathering Company, L.L.P	450,000
Big Horn Gathering Company, L.L.P.	450,000
Bittercreek Gathering Company	0
MIGC, Inc.	130,000
KMGGC, Inc.	140,000
Total	1,804,000

Although Thunder Creek Gas Gathering Company, L.L.P. has not announced any expansion, prior statements by the company suggest the Thunder Creek system could be expanded to a capacity of at least 700,000 million cubic feet (mmcf)/day.

The four interstate pipeline companies or other interstate pipeline companies may seek to expand their systems as the deliverability of CBM gas from the Powder River Basin grows. The expansion of any interstate pipelines would be subject to approval by the Federal Energy Regulatory Commission (FERC). As part of the certification process for any new interstate facilities, FERC's rules and procedures require extensive pre-certification environmental review of such projects. The FERC can condition its approval of new interstate projects with such environmental mitigation practices as indicated by the review of the individual project.

Workforce Requirements

Most of the active workforce involved in developing the Proposed Action would be involved in construction-related activities. After roads and well pads are constructed, pipelines and utility lines are installed, and wells are drilled and completed, minimal personnel would be required to operate the field. Table 2–16 shows the estimated employment requirements for the construction, operation, and reclamation of the project under the Proposed Action.

Construction Resource Requirements

Construction of the project would require a variety of materials and equipment. The primary materials would be water, sand, and gravel. Additionally, small amounts of chemicals would be required. Equipment needed for construction would include heavy equipment (bulldozers, graders, track hoes, trenchers, and front-end loaders) and heavy- and light-duty trucks.

Water would be needed for constructing roads, pipelines, and compressor stations. It also would be needed for drilling wells. Overall, the requirement for water to construct the Proposed Action is expected to be about 6,896 acre-feet (Table 2–17). This water would be obtained from local sources.

Production and Maintenance

Roads

Routine maintenance in the Project Area would occur on a year-round basis or as ground and site conditions permit. This maintenance program includes postponing travel on the two-track roads during and immediately after wet weather when vehicular traffic could cause rutting. Summer (late spring to early fall) road maintenance could include the addition of gravel and/or blading of improved roads consistent with "traveled road maintenance operations" in the area. Other routine maintenance could include borrow ditch grading and culvert and low-water crossing cleanout. Noxious weeds also would require yearly control along roads. Winter (late fall to early spring) maintenance would include blading of snow from access roads and some summer-like maintenance when necessary and permitted by weather conditions. During production and maintenance, the Companies would not routinely employ dust abatement procedures on roads within the Project Area.

Table 2–16 Estimated CBM Employment Requirements for Alternative 1

Work Category	Time Requirements per Unit	Number of Units	Personnel Required (# per year)	Workdays for Project	Workdays per Year	Average # of Workers per Day
Construction and Installation						
Access Roads	1 day/mile	17,276	2	34,552	3,455	14
Well Pads	0.5 day/pad	25,997	1	12,998	1,300	5
Pipelines	2 days/mile	20,474	3	94,164	9,416	39
Electrical Utility Lines	2 days/mile	5,311	5	53,110	5,311	22
Drilling and Casing	4 days/well	39,367	5	787,340	78,734	328
Well Completion	2 days/well	39,367	5	393,670	39,367	164
Compressor Facilities	21 days/compressor	970	28	570,360	57,036	238
Surface Discharge Fac.	5 days/pond	1,216	4	24,320	2,432	10
Infiltration Facilities	30 days/impound.	1,821	6	327,780	32,778	137
Containment Impound.	365 days/impound.	37	7	94,535	9,454	39
Injection well	6.5 days/well	285	6	11,115	1,112	5
Total				2,403,944	240,395	1,001
Operation and Maintenance						
Road/Pad Maintenance	1 days/well	39,367	1	39,367	1,968	8
Pumpers	20 days/well	39,367	1	787,374	39,367	164
Office	2.5 days/well	39,367	2	196,835	9,842	41
Well Workover	4 days/well	39,367	5	787,340	39,367	164
Surface Discharge Fac.	1 day/pond	1,216	1	1,216	61	0.3
Infiltration Facilities	1 day/facility	1,821	1	1,821	91	0.4
Containment Impound.	1 day/facility	37	1	37	4	0.1
Injection well	1 day/well	285	1	285	14	0.7
Total			13	1,814,275	90,714	379
Decommissioning/Reclamation						
Wells	2 days/well	39,367	2	157,468	15,747	66
Roads	2 days/mile	17,276	1	34,552	3,455	14
Compressor Stations	100 days/compressor	970	10	970,000	97,000	404
Reclamation	5 days/facility	313	3	4,695	470	2
Surface Discharge Fac.	2 days/pond	1,216	3	7,296	2,432	10
Infiltration Facilities	10 days/facility	1,821	13	236,730	23,673	99
Containment Impound.	60 days/facility	37	7	15,540	1,554	6
Injection well	2 days/well	285	2	1,140	114	0
Total			41	1,427,421	144,445	601

The counties and Companies would primarily be responsible for maintaining the project's improved roads in the Project Area. The counties would continue to maintain existing county roads. The Companies would maintain all other project roads.

Upon the project's completion, all roads constructed specifically for the project would be removed and reclaimed, unless retention of a road is specifically requested by the landowner or county. If a landowner decides to keep a road, then the landowner would accept responsibility for maintaining the road upon abandonment by the Companies. The counties would continue to maintain existing county roads and any roads covered by maintenance agreements with the BLM.

Table 2–17 Summary of Sand, Gravel, and Water Requirements for Alternative 1

Facility	Amount	Unit	Rate	Total Volume
Sand and Gravel				
Improved roads	6,657	miles	1,173 yd^3/mile	7,808,661
CMFs	394	CMFs	30 yd^3/CMF	11,820
Compressors	313	stations	1,100 yd3/station	344,300
Total (yd^3)				8,164,781
Water				
Roads	17,276	miles	0.1 acre-feet/mile	1,728
Pipelines	1,036	miles	0.04 acre-feet/mile	41
Well drilling	39,367	wells	0.08 acre-feet/well	3,149
Well completion	39,367	wells	0.05 acre-feet/well	1,968
Compressors	970	Compressor	0.01 acre-feet/compressor	10
Total (acre-feet)				6,896

Wells

Routine Maintenance A maintenance person (a "pumper") may visit each well up to once per day to ensure the equipment is functioning properly. Automated well monitoring equipment already in operation allows the pumper to visit less frequently depending on well location, reliability, and other factors. Field personnel would routinely calculate balances between wells and collection/transfer points to ensure volumes match within acceptable tolerances. Significant leaks in gas or water pipelines would cause a loss of pressure detectable by the static pressure on the meter run. If such a leak is detected, a well would be shut-in. The shut-in point would be determined for each well based upon individual operating conditions. Field leaks would then be pinpointed using field pressures and the problem would be corrected. Maintenance of the various mechanical components of the gas production would occur at intervals recommended by manufacturers or as needed based on site visits.

Additional remote (off-site) computerized monitoring system may be installed if warranted by the number of total producing wells and cost effectiveness. If installed, the automated monitoring system would allow remote monitoring of operations at each well. The system would monitor various operating conditions (e.g., gas and water production rates, pipeline pressure, and separator pressure) to determine if abnormal conditions exist. Electrical cables laid to the wells would provide power to the well site automation equipment. The well site operating conditions would be transmitted via radio to a local central facility. If a problem is identified, maintenance personnel would be immediately dispatched to the well site. The radio-controlled system would allow real-time signals and solutions in response to well production problems. Control and monitoring of well production by radio telemetry would reduce regular site inspections of each well and would limit vehicular traffic to approximately once a week to each well. However, other factors, such as the need for visual inspection of gas and water pipelines, may require daily visits for safety and environmental reasons.

Workovers Periodically, a workover on a well would be required. A workover uses a truck-mounted unit similar to a completion rig to ensure that the well is maintained in good condition and is capable of extracting natural gas as efficiently as possible. Workovers are typically needed within the first few months after initial completion to remove coal fines from pumps. Workovers can include repairs to the well bore equipment (casing, tubing, rods, or pumps), the wellhead, or the production formation. These workovers may require venting pressure relief. Routine repairs would occur only during daylight hours and are usually completed within one day. Some limited situations may require several days to complete a workover. Although the frequency of workovers cannot be predicted because the requirements for workovers vary from well to well, each new well would likely require a workover during the first year of production.

Pipelines

Routine inspection of gas-gathering and produced water pipelines would be done during the inspections of facilities. Procedures would be incorporated with the inspection of meters at the well sites. If pressure losses are detected, the wells would be shut in until the problem is isolated and addressed.

Electrical Utilities

Routine inspection and maintenance of electric utilities would be done by utility provider.

Decommissioning and Reclamation

The reclamation of dry holes would follow the procedures described below with the exception that reclamation would begin as soon as possible after the determination is made that the well would not be a producing well or that it is depleted of gas. The following sections describe the overall procedures the Companies would follow to reclaim the disturbance to as near as possible to pre-development conditions.

Roads

At a minimum, access roads would be reclaimed by ripping/plowing and drill seeding unless the landowner and/or land manager wishes to make use of any roads and accepts responsibility through execution of a release for future road maintenance. Improved roads not needed for further use would be blocked, recontoured, reclaimed and vegetated consistent with the requirements of the federal land managers (according to Onshore Oil and Gas Order No. 1, Approval of Operations) and the State of Wyoming. On private lands, the Companies would execute release of the road to the landowner or reclaim it according to the terms of surface use agreements that may be in effect at that time.

All road disturbances on federal lands would be reseeded with a seed mixture approved by the Authorized Officer, as described in the APD Surface Use Program or COAs. The seed mixture would be planted in the amounts specified in pounds of pure live seed per acre. All seed would be certified as weed free. Seed would be tested in accordance with state laws and within 12 months before purchase. Commercial seed either would be certified or registered seed. Seeding

and/or planting would be repeated until satisfactory revegetation is accomplished. Multi-year noxious weed control may be needed on some reclaimed areas.

Wells

All surface facilities would be removed. Depleted production holes would be plugged and abandoned in accordance with Onshore Oil and Gas Order No. 2 and WOGCC's rules. Once the well is conditioned as a static column, the well would be decommissioned by placing redundant plugs, a slurry of cement and water, at strategic locations in the well bore. These locations would be based upon each well's configuration, but would be placed to prevent the migration of fluids or gas up the well bore or any uncemented paths. A mixture of bentonite and water would be placed between the cement plugs. Well pads would be recontoured, plowed, and seeded consistent with the procedures described in the APD Surface Use Program or COAs. The Companies also may assign wells to the landowner consistent with the terms of the surface use agreement. Upon assignment, all rights and responsibilities, including reclamation, pass to the landowner, unless otherwise specified. The landowner must then properly permit the well for beneficial uses after CBM production has ceased according to the WSEO's statutes, procedures, and policies.

Pipelines

The procedures for decommissioning and reclaiming pipelines are straightforward. The underground pipelines would be cleaned, disconnected, and then abandoned in place to avoid any unnecessary surface disturbance as noted in the COAs for the APD or the POD for the ROW or SUP. Any surface disturbances associated with the underground pipelines are addressed in previous sections.

Electrical Utilities

Underground electric lines would be disconnected and abandoned in place to avoid any unnecessary surface disturbance. Aboveground lines would be disconnected and the power poles would be removed from the sites. Surface disturbance associated with the removal would be reclaimed according to the COAs for the APD or the POD for the ROW or SUP.

Non-CBM Development

The BLM has evaluated the potential for the occurrence and development of non-CBM oil and gas resources in the Project Area. In part, this evaluation resulted in the mapping of various levels of potential (e.g., very low, low, moderate, or high) within the Buffalo Field Office Area (BFOA). It also resulted in three levels of potential development, which are documented in the BLM's RFD Scenario for the Buffalo Field Office (BLM 2001f).

The moderate level of development under the BLM's RFD Scenario, which is the basis for this alternative, projects the drilling and completion of about 3,200 non-CBM wells within the Project Area over the 10-year period. As shown on Table 2–18, 3,000 of these wells would be drilled in the portion of the Project Area under the jurisdiction of the Buffalo Field Office (BFO) and FS. The other 200 wells would be drilled in the portion of the Project Area under the jurisdiction of the Casper Field Office (CFO).

Table 2–18 Projected Distribution of Non-CBM Wells Under Alternative 1

Sub-watershed	Potential for Oil and Gas				Total
	Very Low	Low	Moderate	High	
Buffalo Field Office Area and TBNG					
Little Bighorn River	2	0	0	0	2
Upper Tongue River	7	28	0	0	35
Middle Fork Powder River	20	3	0	0	23
North Fork Powder River	1	0	0	0	1
Upper Powder River	0	25	374	0	399
South Fork Powder River	3	3	0	0	6
Salt Creek	0	3	20	0	23
Crazy Woman Creek	1	19	5	0	25
Clear Creek	1	26	0	0	27
Middle Powder River	0	2	57	41	100
Little Powder River	0	0	161	1,358	1,519
Little Missouri River	0	0	4	92	96
Antelope Creek	0	1	82	0	83
Upper Cheyenne River	0	5	35	0	40
Upper Belle Fourche River	0	5	215	401	621
Total	35	120	953	1,892	3,000
Casper Field Office Area					
Converse County					200
Total					3,200

Surface disturbance for a typical oil well (from 5,000 to 12,000 feet deep) includes 4 acres for the well pad and 1.5 acres for a 1-mile long bladed road for a total of 5.5 acres disturbed for drilling operations. Part of the well pad area is reclaimed as production operations begin. The entire area of disturbance is reclaimed when the well is plugged and abandoned.

As shown on Table 2–19, almost 17,600 surface acres of the Project Area may be disturbed by the construction of non-CBM wells. Most of this disturbance would occur in three sub-watersheds. They are Little Powder River, Upper Belle Fourche River, and Upper Powder River. Once the wells are operational and partial reclamation has occurred, long-term disturbance would encompass about 82 percent of the original disturbance.

The non-CBM development also would require a workforce involved in construction-related activities. After roads and well pads are constructed and wells are drilled and completed, minimal personnel would be required to operate the field. Table 2–20 shows the estimated employment requirements for the non-CBM wells.

Safety/Emergency Response

This section outlines the methods that the Companies would employ to ensure the safe operation of the oil and gas wells during development and production. It also describes how the Companies would respond to emergencies. In cooperation with the WOGCC and Wyoming Occupational Safety and Health Administration, the Companies have undertaken a comprehensive study of safety regulations cur-

rently in place related to the development and will recommend to the agencies of jurisdiction any changes deemed necessary to protect the health and safety of the public as well as those employed in the development.

Table 2–19 Projected Maximum Disturbance Due to Non-CBM Wells Under Alternative 1

	Areal Extent of Disturbance	
Sub-watershed	Short-term (acres)	Long-term (acres)
Buffalo Field Office Area and TBNG		
Little Bighorn River	11	9
Upper Tongue River	193	158
Middle Fork Powder River	126	104
North Fork Powder River	6	4
Upper Powder River	2,194	1,796
South Fork Powder River	33	27
Salt Creek	126	104
Crazy Woman Creek	138	112
Clear Creek	148	122
Middle Powder River	550	450
Little Powder River	8,354	6,836
Little Missouri River	528	432
Antelope Creek	456	374
Upper Cheyenne River	220	180
Upper Belle Fourche River	3,416	2,794
Total	16,499	13,502
Casper Field Office Area		
Converse County	1,100	900
Total	17,599	14,402

Note:
Maximum disturbance is based on 5.5 acres and 4.5 acres per well for short-term and long-term disturbances, respectively.

Geologic Hazards

During drilling operations, abnormally-high formation pressure could be encountered, which could result in an uncontrolled well condition. However, more than 6,000 CBM wells have been drilled in the Project Area with no instances of abnormally-high pressure. Blowouts are considered highly unlikely due to the shallow depths of the wells, normal and below normal pressures in the formations, and past experience in the Project Area. The WOGCC and BLM require diverters after setting surface casing.

Fires and Explosions

The potential for leaks or ruptures in gas flowlines or pipelines would exist. Most ruptures are the result of heavy equipment accidentally striking the pipeline while operating in close proximity. Such ruptures could result in an explosion and/or fire if a spark or open flame ignites the escaping gas. The design and selection of materials used in the pipelines would be conducted in accordance with applicable standards to minimize the potential of a leak or rupture. Frequent markers along

the pipelines would reduce the risk of accidental ruptures from excavating equipment. Additionally, the Companies would monitor the pipeline flow by either remote sensors or daily inspections of the flow meters, which would reduce the probability of ruptures by prompt detection of leaks.

Table 2–20 Estimated Non-CBM Employment Requirements for Alternative 1

Work Category	Time Requirements per Unit	Number of Units	Personnel Required (# per year)	Workdays for Project	Workdays per Year	Average # of Workers per Day
Construction and Installation						
Access Roads	1 day/mile	3,200	2	640	64	1
Well Pads	0.5 day/pad	3,200	1	160	16	1
Drilling and Casing	4 days/well	3,200	5	64,000	6,400	27
Well Completion	2 days/well	3,200	5	32,000	3,200	13
Total				96,800	9,680	42
Operation and Maintenance						
Road/Pad Maintenance	1 days/well	1,600	1	1,600	80	1
Pumpers	20 days/well	1,600	1	32,000	1,600	7
Office	2.5 days/well	1,600	2	8,000	400	2
Well Workover	4 days/well	1,600	5	32,000	1,600	7
Total			9	73,600	3,680	17
Decommissioning/Reclamation						
Wells	2 days/well	3,200	2	12,800	1,280	5
Roads	2 days/mile	3,200	1	6,400	640	3
Total			3	19,200	1,920	8

Well fires are very rare, but could occur under certain conditions. For the reasons listed in the previous sections, the probability of a blowout is very low. The Companies will include procedures for reporting and controlling fires in their emergency response programs. The Companies have and would continue to conduct cooperative training exercises with the fire and rescue departments within the Project Area.

Public Safety

The Companies would take measures to protect the public from hazards at well facilities. Warning signs would be placed around facilities, as necessary. Also, compressor stations would be fenced and gated.

Employee Safety

The Companies would develop Emergency Plans that would cover all potential emergencies, including fires, employee injuries, and chemical releases, among others. The Plans would include phone numbers for all medical and emergency services and the people to contact in event of emergencies. In addition, the Companies would not allow firearms to be brought into the area by employees and contractors. The Plans would be posted at all the Companies' local offices and field facilities. All employees and subcontractors would be trained on matters concerning the Emergency Plan when they are hired and refresher courses would be presented annually.

Water Monitoring and Mitigation

Monitoring and mitigation for both ground water and surface water are a substantial part of the Proposed Action. The Companies are conducting, and propose to continue to conduct, hydrologic monitoring to provide information to detect impacts on other water users and to control activities and operations to assure regulatory compliance and public protection.

Mitigation measures include the establishment of monitoring wells and stream gauges. The Companies work with the surface owners to establish water controls, diversions, and uses for the surface discharges. Treatment, injection, and storage may be used where necessary and practicable.

Ground Water

The Wyodak EIS established requirements for the Companies to drill and complete monitoring wells at specific locations throughout the Wyodak Area. The Companies propose to continue this program as part of the Proposed Action. The BLM is currently requiring monitoring well pairs (one in the coal and one in a sand over the coal) for the exploratory PODs well CMFs outside of the Wyodak EIS area. The purpose of these monitoring wells is to provide water level and pressure information to determine possible impacts to other water users.

All operators on federal minerals are required to offer a Water Well Agreement as set forth in the Gillette South EIS and the Wyodak EIS. This agreement protects nearby water wells permitted by the WSEO. The Companies generally offer the same agreement when drilling on fee and State lands.

Surface Water

The Companies are required to monitor and report produced water volumes and quality to WDEQ pursuant to NPDES permit requirements. Discharges are required to meet all applicable WDEQ water quality standards and regulations at all times. The Companies also must report produced water volumes to the WOGCC and WSEO.

The BLM water management plans, FS, and WDEQ require the Companies to use Best Management Practices (BMPs) that would prevent erosion and damage to agricultural activities.

Surface gauging stations may be needed on the Little Powder, Powder, Belle Fourche, Cheyenne, and Tongue Rivers. The cost of this monitoring would be shared among the BLM, the U.S. Department of Interior, Geological Survey (USGS), and the Companies.

The BLM would conduct periodic monitoring of water quality by sampling at discharge points and on streams. The BLM also would monitor selected stream channels receiving CBM discharged water for signs of accelerated erosion and degradation.

In August 2001, the States of Montana and Wyoming signed an Interim MOC to document their commitments and intent to protect and maintain water quality conditions in the PRB within Montana during an 18-month interim period (Ap-

pendix B). At the conclusion of this interim period, the states shall negotiate a final MOC that will include recognition of protective water quality standards and allocation of any assimilative capacity. A monitoring program to implement the interim MOC and to assist in the development of a final MOC is part of the agreement. Currently, the states are developing this monitoring program. Once developed, the aspects of the monitoring plan applicable to the oil and gas development addressed in this EIS would be incorporated into the ROD.

Alternative 2 — Proposed Action with Reduced Emission Levels and Expanded Produced Water Handling Scenarios

Alternative 2 was developed specifically to respond to four of the 18 key issues. They are the issues addressing effects of the Proposed Action on aquifers (Issue 1), the quantity and quality of surface waters (Issues 2 and 3), and effects on air quality and visibility (Issue 6). To respond to these issues, the BLM and FS altered the Proposed Action in two primary areas: the handling of produced water and compression of gas. Other than the differences described below, the rest of Alternative 2 is the same as the Proposed Action.

Methods for Handling Produced Water

The overall methods for handling the disposal of produced water are the same as those included in the Proposed Action. However, the BLM and FS have altered the distribution of produced water among the methods to emphasize handling in two ways. The two emphases are on infiltration and treatment. As shown on (Table 2–21), Alternative 2A emphasizes the use of infiltration impoundments to dispose of CMB produced water. In contrast, Alternative 2B emphasizes the use of passive and active treatment to dispose of CBM produced water (Table 2–22). The emphasis of these alternatives was developed in response to the WDEQ's projections for how CBM produced water probably would have to be handled in the future to meet the Montana–Wyoming Interim Water Quality Criteria MOC (Appendix B).

The changes in water handling methods included as part of Alternatives 2A and 2B slightly alter the number of acres that would be disturbed with their implementation. Instead of affecting 213,115 acres of short-term disturbance as Alternative 1 does, this Alternative 2A would affect 230,886 acres over the short term (Table 2–23). Long-term disturbance associated with Alternative 2A also would be slightly less at 127,693 acres (Table 2–24). In contrast, Alternative 2B would affect 222,860 acres over the short term (Table 2–25) and 119,667 acres over the long term (Table 2–26).

Compression

This alternative includes two options for compression of the CBM, both of which were analyzed in detail. The first option is the electrification of 50 percent of the booster compressors. Under this option, half of the new 1,060 booster compressor units would be electrically powered. The other half would be gas-fired units. The power for the electrical units would be brought to the compressor stations

via the same power lines included in the Proposed Action. Thus, no new external construction would be required. Except for the exchange of gas-fired booster units for electrical booster units, no other visible changes would occur. Reciprocating compressors would remain the same.

Table 2–21 Assumed Water Handling Methods for CBM Wells with an Infiltration Emphasis — Alternative 2A

	Water Handling Method[1,2,3]						
	NPDES-permitted Discharge						
Sub-watershed	Untreated Discharge (percent)	Passive Treatment (percent)	Active Treatment (percent)	Infiltration Impoundment (percent)	Containment Impoundment (percent)	LAD (percent)	Injection (percent)
Upper Tongue River	5	5	0	60	10	10	10
Upper Powder River	5	20	0	55	5	10	5
Salt Creek	0	0	0	60	10	5	25
Crazy Woman Creek	5	5	0	60	10	10	10
Clear Creek	5	5	0	60	10	10	10
Middle Powder River	5	20	0	50	10	10	5
Little Powder River	5	20	0	50	10	10	5
Antelope Creek	0	40	0	40	5	10	5
Upper Cheyenne River	0	40	0	40	5	10	5
Upper Belle Fourche River	30	15	0	30	5	10	10

Notes:

1. The percentages shown represent the distribution of water handling methods assumed for the analysis, not the amount of water that actually reaches the river.
2. Handling Methods:
   NPDES-permitted Discharge – includes methods of handling the produced water that require an NPDES permit.
   Untreated discharge – water that is discharged onto the surface of the ground without any treatment.
   Passive treatment – water that is amended through passive methods to meet standards before discharge. An example of this method is passing the water over scoria to remove iron.
   Active treatment – water that is amended through active methods to meet standards before discharge. An example of this method is passing the water through a reverse osmosis system.
   Infiltration impoundment – water contained in upland and bottomland impoundments designed for maximum infiltration and groundwater recharge.
   Containment impoundment – includes upland impoundments, both lined and unlined, with minimal infiltration and no direct surface discharge or lateral subsurface movement of water and down-gradient expression in seeps or springs. These impoundments may be permitted by either the WOGCC or WDEQ.
   LAD = land application. Typically, land application is achieved by spraying produced water through agricultural irrigation equipment and high-pressure atomizers.
   Injection – represents that water that is injected into disposal wells.
3. The above percentages are not upper thresholds that can or will be enforced. They are merely a disclosure of effects of one of many various ways water may be handled to meet the Montana/Wyoming agreement of water quality levels at the state line.

The second option analyzed under this alternative was the electrification of all 1,060 new booster compressor units. Under this option, no new gas-fired boosters would be constructed. All would be electric. As noted above, no new external construction would be required and the reciprocating compressors would continue to be gas-fired units.

Under both of these options, new power generation capacity would be required to provide the electricity needed to power the electrical booster and reciprocating compressors. The potential locations and sizes of the facilities that could be constructed to provide the necessary additional capacity are too numerous and speculative to evaluate in this analysis.

Table 2–22 Assumed Water Handling Methods for CBM Wells with a Treatment Emphasis — Alternative 2B

	Water Handling Method[1,2,3]						
	NPDES-permitted Discharge						
Sub-watershed	Untreated Discharge (percent)	Passive Treatment (percent)	Active Treatment (percent)	Infiltration Impoundment (percent)	Containment Impoundment (percent)	LAD (percent)	Injection (percent)
Upper Tongue River	5	5	25	35	10	10	10
Upper Powder River	5	20	15	40	5	10	5
Salt Creek	0	0	0	60	10	5	25
Crazy Woman Creek	5	5	20	45	5	10	10
Clear Creek	5	5	20	45	5	10	10
Middle Powder River	5	20	20	30	10	10	5
Little Powder River	5	20	20	35	5	10	5
Antelope Creek	0	30	20	30	5	10	5
Upper Cheyenne River	0	30	20	30	5	10	5
Upper Belle Fourche River	30	20	0	25	5	10	10

Notes:

1. The percentages shown represent the distribution of water handling methods assumed for the analysis, not the amount of water that actually reaches the river.
2. Handling Methods:
   NPDES-permitted Discharge – includes methods of handling the produced water that require an NPDES permit.
   Untreated discharge – water that is discharged onto the surface of the ground without any treatment.
   Passive treatment – water that is amended through passive methods to meet standards before discharge. An example of this method is passing the water over scoria to remove iron.
   Active treatment – water that is amended through active methods to meet standards before discharge. An example of this method is passing the water through a reverse osmosis system.
   Infiltration impoundment – water contained in upland and bottomland impoundments designed for maximum infiltration and groundwater recharge.
   Containment impoundment – includes upland impoundments, both lined and unlined, with minimal infiltration and no direct surface discharge or lateral subsurface movement of water and down-gradient expression in seeps or springs. These impoundments may be permitted by either the WOGCC or WDEQ.
   LAD = land application. Typically, land application is achieved by spraying produced water through agricultural irrigation equipment and high-pressure atomizers.
   Injection – represents that water that is injected into disposal wells.
3. The above percentages are not upper thresholds that can or will be enforced. They are merely a disclosure of effects of one of many various ways water may be handled to meet the Montana/Wyoming agreement of water quality levels at the state line.

As a result of the changes in water handling for alternatives 2A and 2B relative to Alternative 1, additional numbers of employees would be needed to construct, operate, maintain, decommission, and reclaim the facilities. Table 2–27 and Table 2–28 summarize the estimated employment requirements for alternatives 2A and 2B.

Alternative 3 — No Action

The No Action alternative is required by NEPA for comparison to other alternatives analyzed in the EIS. For this analysis, the No Action alternative would not authorize additional natural gas development on Federal leases within the Project Area. Drilling could continue on State and private leases and access and pipelines across Federal lands to reach such proposed State and fee wells would be granted as required by the BLM's policy.

Table 2–23 Summary of Estimated Short-term CBM Disturbance Associated with Alternative 2A

Sub-watershed	Well Pads (acres)	CMFs (acres)	Roads: Improved (acres)	Roads: Two-track (acres)	Poly Pipeline: 2–3-inch (acres)	Poly Pipeline: 12-inch (acres)	Water Handling Facilities[1] (acres)	Compressor Discharge Pipelines: Recip.[2] (acres)	Compressor Discharge Pipelines: Booster[3] (acres)	Power Line: Overhead (acres)	Compressor Stations: Recip. (acres)	Compressor Stations: Booster (acres)	Total[4] (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	632	59	708	2,083	2,077	782	3,961	248	606	782	25	10	11,973
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	4,978	435	4,973	14,556	14,529	5,459	24,751	1,788	4,527	5,459	415	166	82,036
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	11	1	78	351	350	132	61	24	61	132	5	2	1,208
Crazy Woman Creek	774	67	1,030	3,299	3,289	1,235	4,468	291	1,014	1,235	50	20	16,772
Clear Creek	1,009	86	936	3,628	3,620	1,360	5,742	320	605	1,360	35	14	18,715
Middle Powder River	238	22	400	754	752	283	1,284	206	267	283	15	6	4,510
Little Powder River	534	47	818	4,230	4,222	1,586	2,727	218	323	1,586	20	8	16,319
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	474	38	2,076	14,732	14,695	5,524	1,825	127	298	5,524	25	10	45,348
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	160	12	364	663	662	249	592	145	303	249	10	4	3,413
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	1,664	136	1,582	7,190	7,176	2,702	6,168	315	873	2,702	60	24	30,592
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0
Total[3]	10,474	903	12,965	51,486	51,372	19,312	51,579	3,682	8,877	19,312	660	264	230,886

Notes:

1. Disturbance includes the areal extent of direct discharge facilities, containment reservoirs, land application facilities, and injection wells. The ratios of water handling facilities applied to each sub-watershed are shown on Table 2–21.
2. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
3. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.
4. Total may not match precisely with the value obtained by adding unit numbers due to rounding conventions.

Source: BLM 2001e

Table 2–24 Summary of Estimated Long-term CBM Disturbance Associated with Alternative 2A

Sub-watershed	Well Pads (acres)	CMFs (acres)	Roads		Poly Pipeline		Water Handling Facilities[1] (acres)	Compressor Discharge Pipelines		Power Line	Compressor Stations		Total[4] (acres)
			Improved (acres)	Two-track (acres)	2–3-inch (acres)	12-inch (acres)		Recip.[2] (acres)	Booster[3] (acres)	Overhead (acres)	Recip. (acres)	Booster (acres)	
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	259	24	708	2,083	0	0	3,961	0	0	261	25	10	7,331
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	1,897	174	4,973	14,556	0	0	24,751	0	0	1,820	415	166	48,752
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	4	0	78	351	0	0	61	0	0	44	5	2	545
Crazy Woman Creek	292	27	1,030	3,299	0	0	4,468	0	0	412	50	20	9,598
Clear Creek	375	35	936	3,628	0	0	5,742	0	0	453	35	14	11,218
Middle Powder River	96	9	400	754	0	0	1,284	0	0	94	15	6	2,658
Little Powder River	204	19	818	4,230	0	0	2,727	0	0	529	20	8	8,555
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	164	15	2,076	14,732	0	0	1,825	0	0	1,841	25	10	20,688
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	54	5	364	663	0	0	592	0	0	83	10	4	1,775
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	593	55	1,582	7,190	0	0	6,168	0	0	901	60	24	16,573
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0
Total[3]	3,938	363	12,965	51,486	0	0	51,579	0	0	6,438	660	264	127,693

Notes:

1. Disturbance includes the areal extent of direct discharge facilities, containment reservoirs, land application facilities, and injection wells. The ratios of water handling facilities applied to each sub-watershed are shown on Table 2–21.
2. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
3. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.
4. Total may not match precisely with the value obtained by adding unit numbers due to rounding conventions

Source: BLM 2001e

Table 2–25 Summary of Estimated Short-term CBM Disturbance Associated with Alternative 2B

Sub-watershed	Well Pads (acres)	CMFs (acres)	Roads: Improved (acres)	Roads: Two-track (acres)	Poly Pipeline: 2–3-inch (acres)	Poly Pipeline: 12-inch (acres)	Water Handling Facilities[1] (acres)	Compressor Discharge Pipelines: Recip.[2] (acres)	Compressor Discharge Pipelines: Booster[3] (acres)	Power Line: Overhead (acres)	Compressor Stations: Recip. (acres)	Compressor Stations: Booster (acres)	Total[4] (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	632	59	708	2,083	2,077	782	3,120	248	606	782	25	10	11,132
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	4,978	435	4,973	14,556	14,529	5,459	21,053	1,788	4,527	5,459	415	166	78,338
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	11	1	78	351	350	132	61	24	61	132	5	2	1,208
Crazy Woman Creek	774	67	1,030	3,299	3,289	1,235	3,606	291	1,014	1,235	50	20	15,910
Clear Creek	1,009	86	936	3,628	3,620	1,360	4,635	320	605	1,360	35	14	17,608
Middle Powder River	238	22	400	754	752	283	1,035	206	267	283	15	6	4,261
Little Powder River	534	47	818	4,230	4,222	1,586	2,127	218	323	1,586	20	8	15,719
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	474	38	2,076	14,732	14,695	5,524	1,611	127	298	5,524	25	10	45,134
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	160	12	364	663	662	249	522	145	303	249	10	4	3,343
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	1,664	136	1,582	7,190	7,176	2,702	5,783	315	873	2,702	60	24	30,207
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0
Total[3]	10,474	903	12,965	51,486	51,372	19,312	43,553	3,682	8,877	19,312	660	264	222,860

Notes:

1. Disturbance includes the areal extent of direct discharge facilities, containment reservoirs, land application facilities, and injection wells. The ratios of water handling facilities applied to each sub-watershed are shown on Table 2–22.
2. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
3. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.
4. Total may not match precisely with the value obtained by adding unit numbers due to rounding conventions.

Source: BLM 2001e

Table 2–26 Summary of Estimated Long-term CBM Disturbance Associated with Alternative 2B

Sub-watershed	Well Pads (acres)	CMFs (acres)	Roads: Improved (acres)	Roads: Two-track (acres)	Poly Pipeline: 2–3-inch (acres)	Poly Pipeline: 12-inch (acres)	Water Handling Facilities[1] (acres)	Compressor Discharge Pipelines: Recip.[2] (acres)	Compressor Discharge Pipelines: Booster[3] (acres)	Power Line: Overhead (acres)	Compressor Stations: Recip. (acres)	Compressor Stations: Booster (acres)	Total[4] (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	259	24	708	2,083	0	0	3,120	0	0	261	25	10	6,490
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	1,897	174	4,973	14,556	0	0	21,053	0	0	1,820	415	166	45,054
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	4	0	78	351	0	0	61	0	0	44	5	2	545
Crazy Woman Creek	292	27	1,030	3,299	0	0	3,606	0	0	412	50	20	8,736
Clear Creek	375	35	936	3,628	0	0	4,635	0	0	453	35	14	10,111
Middle Powder River	96	9	400	754	0	0	1,035	0	0	94	15	6	2,409
Little Powder River	204	19	818	4,230	0	0	2,127	0	0	529	20	8	7,955
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	164	15	2,076	14,732	0	0	1,611	0	0	1,841	25	10	20,474
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	54	5	364	663	0	0	522	0	0	83	10	4	1,705
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	593	55	1,582	7,190	0	0	5,783	0	0	901	60	24	16,188
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0
Total[3]	3,938	363	12,965	51,486	0	0	43,553	0	0	6,438	660	264	119,667

Notes:

1. Disturbance includes the areal extent of direct discharge facilities, containment reservoirs, land application facilities, and injection wells. The ratios of water handling facilities applied to each sub-watershed are shown on Table 2–22.
2. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
3. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.
4. Total may not match precisely with the value obtained by adding unit numbers due to rounding conventions

Source: BLM 2001e

Table 2–27 Estimated CBM Employment Requirements for Alternative 2A

Work Category	Time Requirements per Unit	Number of Units	Personnel Required (# per year)	Workdays for Project	Workdays per Year	Average # of Workers per Day
Construction and Installation						
Access Roads	1 day/mile	17,276	2	34,552	3,455	14
Well Pads	0.5 day/pad	25,997	1	12,998	1,300	5
Pipelines	2 days/mile	20,474	3	94,164	9,416	39
Electrical Utility Lines	2 days/mile	5,311	5	53,110	5,311	22
Drilling and Casing	4 days/well	39,367	5	787,340	78,734	328
Well Completion	2 days/well	39,367	5	393,670	39,367	164
Compressor Facilities	21 days/compressor	970	28	570,360	57,036	238
Surface Discharge Fac.	5 days/pond	498	4	9,956	996	4
Infiltration Facilities	30 days/impound.	4,032	6	725,688	72,569	302
Containment Impound.	365 days/impound.	43	7	109,993	10,999	46
Injection well	6.5 days/well	342	6	13,333	1,333	6
Total			72	2,805,164	280,516	1,168
Operation and Maintenance						
Road/Pad Maintenance	1 days/well	39,367	1	39,367	1,968	8
Pumpers	20 days/well	39,367	1	787,374	39,367	164
Office	2.5 days/well	39,367	2	196,835	9,842	41
Well Workover	4 days/well	39,367	5	787,340	39,367	164
Surface Discharge Fac.	1 day/pond	498	1	498	25	0.1
Infiltration Facilities	1 day/facility	4,032	1	4,032	202	0.8
Containment Impound.	1 day/facility	43	1	43	4	0.0
Injection well	1 day/well	342	1	342	17	0.1
Total			13	1,815,831	90,792	378
Decommissioning/Reclamation						
Wells	2 days/well	39,367	2	157,468	15,747	66
Roads	2 days/mile	17,276	1	34,552	3,455	14
Compressor Stations	100 days/compressor	970	10	970,000	97,000	404
Reclamation	5 days/facility	313	3	4,695	470	2
Surface Discharge Fac.	2 days/pond	498	3	2,987	299	1
Infiltration Facilities	10 days/facility	4,032	13	524,108	52,411	218
Containment Impound.	60 days/facility	43	7	18,081	1,808	8
Injection well	2 days/well	342	2	1,368	137	1
Total			41	1,713,259	171,327	714

The Department of Interior's authority to implement a "No Action" alternative that precludes development by denying the process is, however, limited. An oil and gas lease grants the lessee the "right and privilege to drill for, mine, extract, remove, and dispose of all oil and gas deposits" in the lease lands, "subject to the terms and conditions incorporated in the lease (Form 3110–2). Because the Secretary of Interior has the authority and responsibility to protect the environment within Federal oil and gas leases, restrictions are imposed on the lease terms.

Table 2–28 Estimated CBM Employment Requirements for Alternative 2B

Work Category	Time Requirements per Unit	Number of Units	Personnel Required (# per year)	Workdays for Project	Workdays per Year	Average # of Workers per Day
Construction and Installation						
Access Roads	1 day/mile	17,276	2	34,552	3,455	14
Well Pads	0.5 day/pad	25,997	1	12,998	1,300	5
Pipelines	2 days/mile	20,474	3	94,164	9,416	39
Electrical Utility Lines	2 days/mile	5,311	5	53,110	5,311	22
Drilling and Casing	4 days/well	39,367	5	787,340	78,734	328
Well Completion	2 days/well	39,367	5	393,670	39,367	164
Compressor Facilities	21 days/compressor	970	28	570,360	57,036	238
Surface Discharge Fac.	5 days/pond	795	4	15,896	1,590	7
Infiltration Facilities	30 days/impound.	2,931	6	527,544	52,754	220
Containment Impound.	365 days/impound.	36	7	91,469	9,147	38
Injection well	6.5 days/well	342	6	13,333	1,333	6
Total			72	2,594,436	259,443	1,081
Operation and Maintenance						
Road/Pad Maintenance	1 days/well	39,367	1	39,367	1,968	8
Pumpers	20 days/well	39,367	1	787,374	39,367	164
Office	2.5 days/well	39,367	2	196,835	9,842	41
Well Workover	4 days/well	39,367	5	787,340	39,367	164
Surface Discharge Fac.	1 day/pond	795	1	795	40	0.2
Infiltration Facilities	1 day/facility	2,931	1	2,931	147	0.6
Containment Impound.	1 day/facility	36	1	36	4	0.0
Injection well	1 day/well	342	1	342	17	0.1
Total			13	1,815,020	90,752	378
Decommissioning/Reclamation						
Wells	2 days/well	39,367	2	157,468	15,747	66
Roads	2 days/mile	17,276	1	34,552	3,455	14
Compressor Stations	100 days/compressor	970	10	970,000	97,000	404
Reclamation	5 days/facility	313	3	4,695	470	2
Surface Discharge Fac.	2 days/pond	795	3	4,769	477	2
Infiltration Facilities	10 days/facility	2,931	13	381,004	38,100	159
Containment Impound.	60 days/facility	36	7	15,036	1,504	6
Injection well	2 days/well	342	2	1,368	137	1
Total			41	1,568,892	156,890	654

On land leased without a No Surface Occupancy or similarly restrictive lease stipulation, the Department of Interior cannot deny a permit to drill. Once the land is leased, the Department no longer has the authority to preclude surface-disturbing activity, even if the environmental impact of such activity is significant. The Department can only impose mitigation measures upon a lessee who pursues surface-disturbing activities. By issuing a lease, the Department has made an irrevocable commitment to allow some surface disturbances (Tenth Circuit Court of Appeals in Sierra Club vs. Peterson [717 F. 2d 1409, 1983]).

Leases within the Project Area contain various stipulations concerning surface disturbance, surface occupancy, limited surface area, and timing restrictions. In

addition, the lease stipulations provide for the imposition of sueh reasonable eonditions, not ineonsistent with the purposes for which the lease was issued, as the (BLM and/or FS) may require to proteet the surfaee of the leased lands and the environment. None of the stipulations, however, would empower the Seeretary of Interior to deny all development activity beeause of environmental concerns. Provisions in leases that expressly provide authority to deny or restriet development in whole or in part depend upon eonformance with certain nondiscretionary statutes, such as the ESA (43 CFR 3101.1–2).

Coal Bed Methane Development

Under this alternative, development of non-federal CBM would eontinue to oeeur on non-federal lands. The ageneies assumed development of fee and state minerals would oecur along the same overall sehedule as for Alternative 1.

As a result, the Companies would drill 15,458 new CBM wells between 2002 and 2011 (Table 2–29). These wells would be in addition to the 12,077 CBM wells already permitted or drilled on federal, state, and private lands. Thus, 27,535 CBM wells would be developed under this alternative by 2011 (Table 2–29).

Table 2–29 Distribution of CBM Wells by Sub-watershed — Alternative 3

	Number of CBM Wells		
Sub-watershed	Pre 2002	2002–2011	Total
Little Bighorn River	0	0	0
Upper Tongue River	815	2,158	2,973
Middle Fork Powder River	0	0	0
North Fork Powder River	0	0	0
Upper Powder River	2,808	4,436	7,244
South Fork Powder River	0	0	0
Salt Creek	0	19	19
Crazy Woman Creek	150	934	1,084
Clear Creek	389	2,488	2,877
Middle Powder River	727	201	928
Little Powder River	1,813	959	2,772
Little Missouri River	0	0	0
Antelope Creek	253	603	856
Dry Fork Cheyenne River	0	0	0
Upper Cheyenne River	454	260	714
Lightning Creek	0	0	0
Upper Belle Fourche River	4,662	3,400	8,062
Middle North Platte River	6	0	6
Total	12,077	15,458	27,535

Source: BLM 2001

As under alternatives 1 and 2, some of the new CBM wells would be drilled from the same well pads. Thus, the number of pads constructed would be less than the number of wells drilled. The Companies would construct a total of 10,534 new well pads between 2002 and 2011 (Table 2–30). With the 9,592 pads constructed or permitted for construction before 2002, this alternative would result in a total of 20,126 well pads by 2011 (Table 2–30).

Table 2–30 Distribution of CBM Well Pads by Sub-watershed — Alternative 3

	Number of CBM Well Pads		
Sub-watershed	Pre 2002	2002–2011	Total
Little Bighorn River	0	0	0
Upper Tongue River	396	974	1,370
Middle Fork Powder River	0	0	0
North Fork Powder River	0	0	0
Upper Powder River	2,253	2,839	5,092
South Fork Powder River	0	0	0
Salt Creek	0	11	11
Crazy Woman Creek	63	629	692
Clear Creek	229	1,739	1,968
Middle Powder River	434	97	531
Little Powder River	1,301	652	1,953
Little Missouri River	0	0	0
Antelope Creek	251	526	777
Dry Fork Cheyenne River	0	0	0
Upper Cheyenne River	389	260	649
Lightning Creek	0	0	0
Upper Belle Fourche River	4,270	2,807	7,077
Middle North Platte River	6	0	6
Total	9,592	10,534	20,126

Source: BLM 2001

Because fewer new wells would be drilled and pads constructed, the number of facilities constructed also would be smaller than under the Proposed Action (Table 2–31). Furthermore, the overall short-term and long-term disturbances associated with this alternative would be less than that which would occur with implementation of Alternative 1 or Alternative 2 (Table 2–32 and Table 2–33).

With fewer wells overall, implementation of this alternative also would result in smaller amounts of produced water and gas. Table 2–34 and Table 2–35 show the amounts of water and gas projected for this alternative, respectively.

Table 2–31 Summary of New Facilities Comprising Alternative 3

Sub-watershed	Well[3] Pads	Roads		Poly Pipeline		Steel Pipeline	Electrical Line	Recip Compressors[1]		Booster Compressors[2]	
		Improved (miles)	Two-track (miles)	2–3-inch (miles)	12-inch (miles)	12-inch (miles)	Overhead (miles)	(units)	(horsepower)	(units)	(horsepower)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	974	184	367	488	184	60	184	7	11,550	25	8,750
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	2,839	360	720	958	360	125	360	44	72,600	161	56,350
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	11	0	0	0	0	4	0	1	1,650	2	700
Crazy Woman Creek	629	113	226	300	113	36	113	7	11,550	23	8,050
Clear Creek	1,739	252	504	670	252	51	252	9	14,850	32	11,200
Middle Powder River	97	16	32	43	16	8	16	0	0	2	700
Little Powder River	652	225	450	598	225	23	225	4	6,600	14	4,900
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	526	551	1,101	1,465	551	13	551	4	6,600	15	5,250
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	260	33	67	89	33	18	33	2	3,300	8	2,800
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	2,807	436	870	1,158	436	58	436	19	31,350	68	23,800
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0
Total	10,534	2,170	4,337	5,769	2,170	396	2,170	97	160,050	350	122,500

Notes:

1. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
2. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.
3. Total may not match precisely with the value obtained by adding unit numbers due to rounding conventions.

Source: BLM 2001e

Table 2–32 Summary of Estimated Short-term Disturbance Associated with Alternative 3

Sub-watershed	Well Pads (acres)	CMFs (acres)	Roads		Poly Pipeline		Water Handling Facilities[1] (acres)	Compressor Discharge Pipelines		Power Line	Compressor Stations		Total[4] (acres)
			Improved (acres)	Two-track (acres)	2–3-inch (acres)	12-inch (acres)		Recip.[2] (acres)	Booster[3] (acres)	Overhead (acres)	Recip. (acres)	Booster (acres)	
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	632	50	223	1,781	1,776	669	2,600	212	518	669	10	8	9,148
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	4,978	102	436	3,490	3,483	1,309	2,906	429	1,085	1,309	30	38	19,595
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	11	0	13	104	20	39	17	12	31	39	5	2	293
Crazy Woman Creek	774	22	136	1,093	1,090	409	672	96	336	409	5	6	5,048
Clear Creek	1,009	57	305	2,441	2,436	916	2,911	215	407	916	10	10	11,633
Middle Powder River	238	5	20	157	157	59	165	43	56	59	0	2	961
Little Powder River	534	22	273	2,180	2,176	818	786	112	166	818	5	4	7,894
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	474	14	668	5,340	5,328	2,003	552	46	108	2,003	5	4	16,545
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	160	6	41	324	323	122	238	71	148	122	0	2	1,557
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	1,665	78	529	4,220	4,211	1,586	3,537	185	512	1,586	10	14	18,133
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0
Total[3]	10,475	356	2,644	21,130	21,000	7,930	14,384	1,421	3,367	7,930	80	90	90,807

Notes:

1. Disturbance includes the areal extent of direct discharge facilities, containment reservoirs, land application facilities, and injection wells. The ratios of water handling facilities applied to each sub-watershed are shown on Table 2–9.
2. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
3. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.
4. Total may not match precisely with the value obtained by adding unit numbers due to rounding conventions.

Source: BLM 2001e

Table 2–33 Summary of Estimated Long-term Disturbance Associated with Alternative 3

Sub-watershed	Well Pads (acres)	CMFs (acres)	Roads Improved (acres)	Roads Two-track (acres)	Poly Pipeline 2–3-inch (acres)	Poly Pipeline 12-inch (acres)	Water Handling Facilities[1] (acres)	Compressor Discharge Pipelines Recip.[2] (acres)	Compressor Discharge Pipelines Booster[3] (acres)	Power Line Overhead (acres)	Compressor Stations Recip. (acres)	Compressor Stations Booster (acres)	Total[4] (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	259	20	223	1,781	0	0	2,600	0	0	223	10	8	5,124
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	1,897	41	436	3,490	0	0	2,906	0	0	437	30	38	9,275
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	4	0	13	104	0	0	17	0	0	13	5	2	158
Crazy Woman Creek	292	9	136	1,093	0	0	672	0	0	137	5	6	2,350
Clear Creek	375	23	305	2,441	0	0	2,911	0	0	306	10	10	6,381
Middle Powder River	96	2	20	157	0	0	165	0	0	20	0	2	462
Little Powder River	204	9	273	2,180	0	0	786	0	0	273	5	4	3,734
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	164	6	668	5,340	0	0	552	0	0	669	5	4	7,408
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	54	2	41	324	0	0	238	0	0	41	0	2	702
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	593	31	529	4,220	0	0	3,537	0	0	529	10	14	9,463
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0
Total[3]	3,938	143	2,644	21,130	0	0	14,384	0	0	2,648	80	90	45,057

Notes:

1. Disturbance includes the areal extent of direct discharge facilities, containment reservoirs, land application facilities, and injection wells. The ratios of water handling facilities applied to each sub-watershed are shown on Table 2–9.
2. Reciprocating (Recip.) compressors increase the compression of natural gas for delivery to high-compression transmission pipelines. Each station would consist of 1 to 6 recip compressors, depending upon the volume of gas being delivered to the station.
3. Booster compressors enhance the flow of gas from the wells to the recip compressors. Each station would consist of 1 to 6 booster compressors, depending upon the volume of gas being delivered to the station.
4. Total may not match precisely with the value obtained by adding unit numbers due to rounding conventions.

Source: BLM 2001e

Table 2–34 Projected Amount of Water Produced from CBM Wells Under Alternative 3

Sub-watershed	Water Produced (acre-feet)[1]																
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	14,207	20,707	25,788	27,619	28,922	29,016	28,324	28,804	27,525	27,461	18,794	11,629	6,029	2,476	1,046	361	298,708
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	68,362	79,569	84,454	81,929	75,264	78,385	67,532	50,015	34,029	22,484	12,551	6,812	3,029	1,062	437	153	666,067
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	158	135	135	200	293	229	163	93	56	27	10	0	0	0	0	0	1,499
Crazy Woman Creek	7,315	10,975	14,030	15,954	16,079	15,934	14,947	12,216	11,233	10,487	7,166	4,484	2,312	970	338	111	144,551
Clear Creek	15,151	26,246	35,117	38,360	39,582	39,564	39,230	36,008	34,535	34,411	23,950	15,177	7,856	3,364	1,136	392	390,079
Middle Powder River	10,444	8,165	6,259	4,436	2,900	2,388	1,950	2,091	1,576	1,502	984	654	348	184	68	32	43,981
Little Powder River	19,531	16,128	12,201	9,825	8,581	6,814	6,163	5,349	5,578	4,875	3,288	1,882	983	448	256	92	101,994
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	4,695	5,067	5,059	4,919	4,700	4,845	4,527	3,693	2,757	2,043	1,266	772	379	161	84	29	44,996
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	6,957	6,185	5,219	4,191	3,198	2,958	2,560	2,009	1,697	1,212	778	430	226	95	40	8	37,763
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	59,592	51,467	43,558	35,112	30,988	29,491	25,519	19,461	13,975	10,057	6,081	3,556	1,732	653	300	164	331,706
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	206,412	224,644	231,820	222,545	210,507	209,624	190,915	159,739	132,961	114,559	74,868	45,396	22,894	9,413	3,705	1,342	2,061,344

Note:

1. Volumes shown include produced water from pre-2002 wells as well as the new CBM wells.

Source: BLM 2001e

Table 2–35 Projected Amounts of Natural Gas Produced from CBM Wells Under Alternative 3

	Total Cubic Feet of Methane Produced per Day by Year (in mmcf)									
Sub-watershed	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Little Bighorn River	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	18	30	47	60	70	74	76	77	77	77
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0
Upper Powder River	252	399	481	534	542	538	520	446	308	192
South Fork Powder River	0	0	0	0	0	0	0	0	0	0
Salt Creek	4	6	7	8	8	7	7	6	4	2
Crazy Woman Creek	31	50	63	72	75	75	74	66	51	38
Clear Creek	37	58	76	89	97	101	103	102	97	93
Middle Powder River	2	3	4	5	5	6	6	6	6	6
Little Powder River	26	39	45	49	50	50	51	49	43	38
Little Missouri River	0	0	0	0	0	0	0	0	0	0
Antelope Creek	29	44	50	54	54	53	52	45	33	23
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	15	22	25	27	27	27	27	27	23	20
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	161	228	252	264	261	260	257	233	180	132
Middle North Platte River	0	0	0	0	0	0	0	0	0	0
Total	575	879	1,050	1,162	1,189	1,191	1,173	1,057	822	621

Source: BLM 2001e

Drilling and Construction of Facilities

Electrical Power Utilities

Based on projected power demands, it is anticipated that the Companies would require 0.5 MW per day to transport 3 bcf of natural gas per day using gas-fired compression. Based on this power demand, the maximum power requirement would be 0.6 MW per day.

Under this alternative, three-phase 24.9-kV distribution lines would connect wells and compressor facilities with the existing transmission and distribution system within the Project Area. Electricity would be routed to compressor stations and CMFs aboveground on poles generally located along the access roads or on additional rights-of-way (30 feet wide) across open land. Between the CMFs and wells, the secondary electric service power lines (480 volt) would be buried in the same trenches with the gas- and produced water-gathering pipelines. The installation and power would be provided by the utility company providing these services. Construction of the power lines would follow access road development and coincide with the completion of well drilling. The power lines would be designed and constructed according to the Avian Power Line Interaction Committee's (1996) guidelines for the prevention of electrocution of raptors.

The aboveground power lines would be constructed using tracked and wheeled equipment. Holes for the poles would be located to not disturb existing sensitive vegetation and would be excavated to a depth of 6 to 8 feet. Poles and other structural components would be transported to the construction site where they would be assembled and then erected by a boom truck.

Pole locations could be moved within the 30-foot wide ROW if topography and/or impacts to cultural, vegetative, or wildlife resources are identified at the site of the structure. In areas of thick vegetation and/or where vegetation may impede the performance of the active line, vegetation would be cleared, typically with hand-held equipment. Where areas of sensitive plant resources are known to occur, the BLM would be consulted before removal of any vegetation.

All aboveground electric lines typically would be installed on 35-foot tall poles. Poles would be required approximately every 300 feet. Approximately 2,170 miles of aboveground power lines would be installed in the Project Area (Table 2–31). The short-term disturbance for these lines would be 7,930 acres (Table 2–32).

Workforce Requirements

Most of the active workforce involved in developing Alternative 3 would be involved in construction-related activities. After roads and well pads are constructed, pipelines and utility lines are installed, and wells are drilled and completed, minimal personnel would be required to operate the field. Table 2–36 shows the estimated employment requirements for the construction, operation, and reclamation of the project under Alternative 3.

Table 2–36 Estimated CBM Employment Requirements for Alternative 3

Work Category	Time Requirements per Unit	Number of Units	Personnel Required (# per task)	Workdays for Project	Workdays per Year	Average # of Workers per Day
Construction and Installation						
Access Roads	1 day/mile	6,507	2	13,014	1,301	5
Well Pads	0.5 day/pad	10,534	1	5,267	527	2
Pipelines	2 days/mile	8,335	3	50,010	5,001	21
Electrical Utility Lines	2 days/mile	2,170	5	21,700	2,170	9
Drilling and Casing	4 days/well	15,458	5	309,160	30,916	129
Well Completion	2 days/well	15,458	5	154,580	15,458	64
Compressor Facilities	21 days/compressor	60	28	35,280	3,528	15
Surface Discharge Fac.	5 days/pond	419	4	8,376	838	3
Infiltration Facilities	30 days/facility	893	6	160,668	16,067	67
Containment Impound.	365 days/impound.	16	7	39,986	3,999	17
Injection well	6.5 days/well	147	6	5,728	573	2
Total				803,769	80,378	334
Operation and Maintenance						
Road/Pad Maintenance	1 days/well	15,458	1	15,458	773	3
Pumpers	20 days/well	15,458	1	309,160	15,458	64
Office	2.5 days/well	15,458	2	69,561	3,478	14
Well Workover	4 days/well	15,458	5	309,160	15,458	64
Surface Discharge Fac.	1 day/pond	419	1	419	21	0.1
Infiltration Facilities	1 day/facility	893	1	893	45	0.2
Containment Impound.	1 day/impound.	16	1	16	2	0.0
Injection well	1 day/well	147	1	147	7	0.0
Total			13	704,814	35,242	145
Decommissioning/Reclamation						
Wells	2 days/well	15,458	2	61,832	6,183	26
Roads	2 days/mile	6,507	1	13,014	1,301	5
Compressor Stations	100 days/compressor	60	10	60,000	6,000	25
Reclamation	5 days/facility	127	3	145,161	14,516	60
Surface Discharge Fac.	2 days/pond	419	3	2,513	251	1
Infiltration Facilities	10 days/facility	893	13	116,038	251	1
Containment Impound.	60 days/impound.	16	7	6,573	657	3
Injection well	2 days/well	147	2	588	59	0
Total			41	405,719	29,218	121

Construction Resource Requirements

Construction of the project would require a variety of materials and equipment. The primary materials would be water, sand, and gravel. Additionally, small amounts of chemicals would be required. Equipment needed for construction would include heavy equipment (bulldozers, graders, track hoes, trenchers, and front-end loaders) and heavy- and light-duty trucks.

Water would be needed for constructing roads, pipelines, and compressor stations. It also would be needed for drilling wells. Overall, the requirement for water to construct Alternative 3 is expected to be about 6,896 acre-feet (Table 2–37). This water would be obtained from local sources.

Table 2–37 Summary of Sand, Gravel, and Water Requirements for Alternative 3

Facility	Amount	Unit	Rate	Total Volume
Sand and Gravel				
Improved roads	6,657	miles	1,173 yd^3/mile	7,808,661
CMFs	1,546	CMFs	30 yd^3/CMF	46,380
Compressors		stations	1,100 yd3/station	344,300
Total (yd^3)				8,199,341
Water				
Roads	6,507	miles	0.1 acre-feet/mile	651
Pipelines	7,939	miles	0.04 acre-feet/mile	317
Well drilling	15,458	wells	0.08 acre-feet/well	1,237
Well completion	15,458	wells	0.05 acre-feet/well	773
Compressors		Compressor	0.01 acre-feet/compressor	10
Total (acre-feet)				2,988

Non-CBM Development

As with the CBM wells, development of non-federal CBM would continue to occur on non-federal lands. The agencies assumed development would be proportional to the areal extent of private and state minerals present in the Project Area. Table 2–38 shows the projected distribution of non-CBM wells for Alternative 3.

Surface disturbance for a typical non-CBM well includes 2 acres for the well pad and 1.5 acres for a 1 mile bladed road for a total of 3.5 acres disturbed for drilling operations. Surface disturbance for a typical deep oil well (from 5,000 to 12,000 feet deep) includes 4 acres for the well pad and 1.5 acres for a 1 mile bladed road for a total of 5.5 acres disturbed for drilling operations. Part of the well pad area is reclaimed for production operations, and the entire area of disturbance is reclaimed when the well is plugged and abandoned.

As shown on Table 2–39, almost 17,600 surface acres of the Project Area may be disturbed by the construction of non-CBM wells. Most of this disturbance would occur in three watersheds. They are Little Powder River, Upper Belle Fourche River, and Upper Powder River. Once the wells are operational and partial reclamation has occurred, long-term disturbance would encompass about 82 percent of the original disturbance.

The non-CBM development also would require a workforce involved in construction-related activities. After roads and well pads are constructed and wells are drilled and completed, minimal personnel would be required to operate the field. Table 2–40 shows the estimated employment requirements for the non-CBM wells.

Table 2–38 Projected Distribution of Non-CBM Wells Under Alternative 3

Sub-watershed	Potential for Oil and Gas				Total
	Very Low	Low	Moderate	High	
Buffalo Field Office Area					
Little Bighorn River	1	0	0	0	1
Upper Tongue River	3	12	0	0	15
Middle Fork Powder River	9	1	0	0	10
North Fork Powder River	1	0	0	0	1
Upper Powder River	0	11	165	0	176
South Fork Powder River	1	1	0	0	2
Salt Creek	0	1	9	0	10
Crazy Woman Creek	1	8	2	0	11
Clear Creek	1	11	0	0	12
Middle Powder River	0	1	25	18	44
Little Powder River	0	0	71	598	669
Little Missouri River	0	0	2	41	43
Antelope Creek	0	1	36	0	37
Upper Cheyenne River	0	2	15	0	17
Upper Belle Fourche River	0	2	95	176	273
Total	17	51	420	833	1,321
Casper Field Office Area					
Converse County					88
Total					1,409

Alternatives Considered but Eliminated from Detailed Analysis

Several potential alternatives were considered for this analysis, but were dropped from detailed study for various reasons. These alternatives are listed below and the reasons they were excluded from further consideration are described.

Alternative Considered: Return all produced water to aquifers

Reasons Considered: This alternative was specifically developed to respond to issues about effects to aquifers and soils and the quantity and quality of surface water in and downstream of the Project Area. Under this alternative, the Companies would capture and actively return produced water to aquifers. Methods for accomplishing this return include storage and retrieval wells, infiltration pits, land application (e.g., spreaders and sprinklers), infiltration at clinker zones, and leach fields.

Table 2–39 Projected Maximum Disturbance Due to Non-CBM Wells Under Alternative 3

Sub-watershed	Areal Extent of Disturbance: Short-term (acres)	Areal Extent of Disturbance: Long-term (acres)
Buffalo Field Office Area and TBNG		
Little Bighorn River	6	4
Upper Tongue River	82	68
Middle Fork Powder River	55	45
North Fork Powder River	6	4
Upper Powder River	968	792
South Fork Powder River	11	9
Salt Creek	55	45
Crazy Woman Creek	60	50
Clear Creek	66	54
Middle Powder River	242	198
Little Powder River	3,680	3,010
Little Missouri River	236	194
Antelope Creek	204	166
Upper Cheyenne River	94	76
Upper Belle Fourche River	1,502	1,228
Total	7,267	5,943
Casper Field Office Area		
Converse County	484	396
Total	7,751	6,339

Note:
Maximum disturbance is based on 5.5 acres and 4.5 acres per well for short-term and long-term disturbances, respectively.

Table 2–40 Estimated Non-CBM Employment Requirements for Alternative 3

Work Category	Time Requirements per Unit	Number of Units	Personnel Required (# per year)	Workdays for Project	Workdays per Year	Average # of Workers per Day
Construction and Installation						
Access Roads	1 day/mile	1,345	2	2,690	269	1
Well Pads	0.5 day/pad	1,345	1	672	67	1
Drilling and Casing	4 days/well	1,345	5	26,900	2,690	11
Well Completion	2 days/well	1,345	5	13,450	1,345	6
Total				43,712	4,371	19
Operation and Maintenance						
Road/Pad Maintenance	1 days/well	673	1	673	34	1
Pumpers	20 days/well	673	1	13,460	673	3
Office	2.5 days/well	673	2	1,682	84	1
Well Workover	4 days/well	673	5	13,460	673	3
Total			9	29,275	1,464	8
Decommissioning/Reclamation						
Wells	2 days/well	1,345	2	5,380	538	2
Roads	2 days/mile	1,345	1	2,690	269	1
Total			3	8,070	807	3

Reasons Dropped:	The feasibility of an all re-injection alternative appears to be limited. The BLM and FS could not require the Companies to implement this alternative. Much of the Project Area involves non-federal minerals and non-federal surface over which the BLM and FS have no jurisdiction. Thus, they could not legally require the Companies to return produced water to aquifers where the agencies do not have the legal authority. Furthermore, the alternatives considered in detail involve returning at least a portion of the produced water to aquifers.
Alternative Considered:	Capture and treat produced water for additional beneficial uses.
Reasons Considered:	Under this alternative, the Companies would capture the produced water, treat it, and make it available for additional beneficial uses. These uses include stock watering, wildlife habitat (aquatic, wetlands, and riparian), recreational opportunities (e.g., hunting of waterfowl), and irrigation. In addition to responding to the issues about effects to aquifers and soils and the quantity and quality of surface water in and downstream of the Project Area, this alternative was developed to respond to effects on terrestrial and aquatic wildlife and recreational opportunities.
Reasons Dropped:	This alternative technically would not be feasible over the long term. Each CBM well is expected to produce water for a maximum of seven years with a peak in production occurring during the initial few years. If the agencies required the Companies to treat the produced water and make it available to additional beneficial uses, these uses essentially would be relatively short term in nature. Once the produced water from specific wells diminishes, the beneficial uses supported by that water also would diminish. Thus, beneficial uses also would be short term in nature wherever they would occur.
Alternative Considered:	Staged rate of development.
Reasons Considered:	This alternative was developed in response to a variety of the issues raised during scoping, including concerns about the volume of water discharged to local drainages. Under this alternative, the Companies would control the number of rigs operating in the Project Area and would

	develop their leases in stages. The number of rigs working in the Project Area would be less than the number currently working in the area.
Reasons Dropped:	The BLM and FS have no legal authority to control how the Companies develop their leases, as long as they meet the Conditions of Approval and requirements of all their other permits. Furthermore, much of the minerals and surface in the Project Area are owned by the State of Wyoming or private parties. The BLM and FS have no legal authority to direct the Companies how they should develop these leases. Additionally, the BLM and FS have a legal obligation to ensure that leased federal minerals are fully developed and that federal minerals are not drained by production occurring on non-federal leases.

Alternative Considered:	No action on all lands.
Reasons Considered:	This alternative was considered as a true No Action alternative under NEPA. Under this alternative, no further drilling or development of oil or gas wells would occur anywhere within the Project Area.
Reasons Dropped:	This alternative was dropped from detailed consideration because it was not at all feasible. Development of fee and state minerals, particularly those already leased, would continue regardless of the BLM and FS' decisions. Because the development of fee and state minerals undoubtedly will occur, the BLM and FS decided a No Action alternative that involved development of fee and state minerals without the development of federal minerals would more closely resemble the actual situation of the BLM and FS denying any further development of CBM from federal minerals.

Alternative Considered:	Surface discharge produced water, but ensure water quality at the Wyoming–Montana border does not change enough to adversely affect the uses of water at and downstream of the Wyoming–Montana border.
Reasons Considered:	This alternative was considered as a means to address the State of Montana's concerns about the quality of surface water entering the State. Under this alternative, the quality and quantity of discharges of produced water would be moni-

tored to ensure any changes in water quality at the Montana-Wyoming State Line would be insufficient to affect downstream uses of that water in Montana.

Reasons Dropped:

The signing and implementation of the Montana and Wyoming Powder River Interim Water Quality Criteria Memorandum of Cooperation essentially eliminated this alternative. If the water monitoring conducted under this agreement suggests produced water discharging into the rivers and subsequently into Montana may not be meeting the interim criteria, the Companies would have to discontinue discharging the produced water that is the source of the problems. The thresholds or criteria identified in the agreement are well below those that would result in interference with the existing uses of water. Therefore, the discharging of produced water would be discontinued before the produced water would interfere with any downstream uses of the water.

Impact and Mitigation Monitoring and Reporting

Appendix D of this EIS contains a framework for a Mitigation Monitoring and Reporting Plan (MMRP) that would be adopted for this project. This framework was developed to:

- Verify implementation of mitigation measures adopted in the ROD;
- Measure the success rate of those mitigation measures:
- Make appropriate modifications to mitigation based on actual performance;
- Allow for peer review of mitigation and monitoring results; and
- Provide feedback to the interested public.

Summary of Alternatives and Environmental Consequences

The following tables summarize the alternatives considered in detail and the likely environmental consequences of each alternative. Table 2–41 contains the summary of alternatives. This table contrasts the four alternatives in terms of their physical characteristics. The matrix presented in Table 2–42 provides a comparison summary of the effects to the various environmental resources that would be realized by implementing each of the four alternatives for the Powder River Basin Oil and Gas Project.

Agency-Preferred Alternative

The BLM's preferred alternative is Alternative 1 — Proposed Action. This alternative provides for the best balance of effects to costs and development of the CBM. Most of the federal minerals in the Project Area have already been leased. The pattern of federal and non-federal mineral ownership coupled with the BLM's responsibilities under 43 CFR 3162.2 to prevent drainage of federal oil and gas preclude the BLM from choosing Alternative 3 as the preferred alternative.

Alternatives 2A and 2B offer some advantages over Alternative 1; however, the advantages are insufficient to justify the additional costs and disturbance. Both alternatives 2A and 2B would increase short- and long-term disturbance over Alternative 1 by at least 10 percent. However, as documented in the analysis they would not substantially decrease effects to air quality, visibility, and water quality — the primary issues for which the alternatives were developed. The amount of CBM water produced by alternatives 1, 2A, and 2B would be the same. The costs of implementing the water handling procedures of alternatives 2A and 2B would be substantially higher than those associated with Alternative 1, but the difference between the effects of these two alternatives and Alternative 1 does not reflect or justify these additional costs. The analysis documents that the benefits to air quality and visibility from electrifying half or all of the booster compressors would be insufficient to justify the additional costs of requiring the Companies to use electric booster compressors. It is estimated that few booster compressors would be built on surface that is federally owned and BLM does not have the ability to require electrification of compressors constructed off of federal surface. The permitting of the compressors is the responsibility of the State of Wyoming.

Table 2–41 Summary Comparison of Alternatives Considered in Detail

Parameter	Alternative 1	2A	2B	3
New CBM Facilities				
Number of Wells				
Federal ownership	23,909	23,909	23,909	0
Non-federal ownership	15,458	15,458	15,458	15,458
Total	39,367	39,367	39,367	15,458
Number of Well Pads				
Federal ownership	15,455	15,455	15,455	0
Non-federal ownership	10,542	10,542	10,542	10,542
Total	25,997	25,997	25,997	10,542
Roads (miles)				
Improved	6,657	6,657	6,657	2,170
Two-track	10,619	10,619	10,619	4,337
Pipeline (miles)				
2–3-inch poly	14,127	14,127	14,127	5,769
12-inch poly	5,311	5,311	5,311	2,170
12-inch steel	1,036	1,036	1,036	396
Overhead Electric Line (miles)	5,311	5,311	5,311	3,170
Compressors				
Number of booster units	1,060	1,060	1,060	350
Number of booster stations	186	186	186	175
Total horsepower of booster units	371,000	371,000	371,000	122,500
Number of reciprocating units	298	298	298	97
Number of reciprocating stations	63	63	63	19
Total horsepower of reciprocating units	491,700	491,700	491,700	160,050
Water Handling Facilities				
Analyzed number of surface discharge facilities	1,216	498	795	419
Analyzed number of infiltration facilities	1,821	4,032	2,931	893
Analyzed number of containment impoundments	37	43	36	16
Analyzed number of injection wells	285	342	342	147
Projected Short-term Disturbance (acres)	211,992	230,886	222,860	90,807
Projected Long-term Disturbance (acres)	108,799	127,693	119,667	45,057
Workforce Requirements				
Construction and installation (number of workdays)	2,403,944	2,805,164	2,594,436	803,769
Operation and maintenance (number of workdays)	1,814,275	1,815,831	1,815,020	704,814
Reclamation and abandonment (number of workdays)	1,427,421	1,713,259	1,568,892	405,719
New non-CBM Facilities				
Number of new wells				
Federal ownership	1,791	1,791	1,791	0
Non-federal ownership	1,409	1,409	1,409	1,409
Total	3,200	3,200	3,200	1,409
Projected short-term disturbance (acres)	17,599	17,599	17,599	7,751
Projected long-term disturbance (acres)	14,402	14,402	14,402	6,339
Workforce Requirements				
Construction and installation (number of workdays)	96,800	96,800	96,800	43,712
Operation and maintenance (number of workdays)	73,600	73,600	73,600	29,275
Reclamation and abandonment (number of workdays)	19,200	19,200	19,200	8,070

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Groundwater				
Maximum Drawdown				
Fort Union Formation	300–1,200 feet	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Deep Wasatch Sands	10–250 feet	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Shallow Wasatch Sands	1–50 feet (in areas of thin Wasatch cover)	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	-1 to –50 feet (below impoundments and creeks receiving CBM discharge)	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Period of Maximum Drawdown				
Fort Union Formation	2006–2009	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Deep Wasatch Sands	2009–2018	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Shallow Wasatch Sands	2006–2012 (drawdown areas) 2006–2009 (buildup areas)	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Recharge	Recharge of shallow Wasatch increased during CBM development due to infiltration below creeks and impoundments receiving CBM discharge water.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Quality	Groundwater quality within the regional aquifer systems and alluvial aquifers would not be noticeably affected.	Same as Alternative 1	Same as Alternative 1.	Same as Alternative 1
Recovery	Rapid initial recovery of water levels in developed coals following cessation of CBM pumping. Typically >80% recovery within first 10 years. Recovery to within 20 to 50 feet of pre-development water levels occurs over 50 to 100 years. Similar pattern for deep Wasatch Sands but lagged by about 10 years.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	2A	2B	3
Springs/Wells	Wells completed in developed coals within 10 miles of CBM development are likely to experience water level drops and possibly methane occurance. Flowing artesian wells and springs that are sourced within coals in this area are likely to experience decrease in flow rate. Wells and springs in Wasatch are not expected to be substantially affected unless they are within 100 feet (vertically) of developed coal.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Surface Water				
Quantity	Perennial flows likely to develop in formerly ephemeral channels	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	High seasonal flows expected to rise	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
CBM Produced Water discharged to surface	476,216 acre-feet	179,171 acre-feet	270,781 acre-feet	181,807 acre-feet
Quality	Negligible changes in water quality of main stems.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	Concentrations of suspended sediment in surface waters likely to rise above present levels due to runoff from disturbed areas.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	SAR values and sodium concentrations may inhibit the use of irrigation on some tributaries.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	Evaporation may cause concentrations of salts and other metals in impoundments and surface drainages.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Surface Drainages	Erosion of surface drainages would occur due to increased flows.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	Channels are more likely to overbank during snowmelt due to increased flows from CBM discharges	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Surface Waterbodies	Reservoirs downstream likely would receive more water and could receive more sediment.	Numerous impoundments would serve as flood control structures during high seasonal flows.	Same as Alternative 1	Same as Alternative 1
	Springs may develop in drainages where infiltration is enhanced.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Surface Water Use	Increased availability of surface water for irrigation and other downstream beneficial uses.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
	Potential reduction of flows by impoundments may diminish water availability to permitted water right holders downstream	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Physiography, Geology,Paleontology, and Minerals				
Paleontology	If Class 3, 4, or 5 formations are present in areas of disturbance, ground-disturbing activities could damage or destroy surface and sub-surface fossils.	Similar to Alternative 1, but with a higher potential due to a larger amount of disturbance.	Similar to Alternative 1, but with a higher potential due to a larger amount of disturbance.	Similar to Alternative 1, but with a reduced potential due to a smaller amount of disturbance.
Minerals	Would produce about 16 trillion cubic feet of CBM.	Same as Alternative 1	Same as Alternative 1	Would produce about 8 trillion cubic feet of CBM.
	Would produce about 220 million barrels of oil equivalent from the non-CBM wells.			Would produce about 100 million barrels of oil equivalent from the non-CBM wells.
Geological Hazards	Implementation is unlikely to cause noticeable ground subsidence or increase the potential for underground coal fires. Migration of some CBM could occur within the PRB as development of CMB occurs.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1. but to a smaller extent due to the smaller number of wells.
Soils				
Erosional effects from facilities located on soils with high wind erosion potential	Increased wind erosion due to removal of vegetation, excavation, and stockpiling of soil, especially in sandy soils. Approximately 25,474 acres in the short term and 13,403 acres in the long term would be disturbed on soils with a high wind erosion potential.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for wind erosion would increase slightly.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase impoundments, the potential for wind erosion would increase slightly, but increase would be less than in Alternative 2A.	All disturbance would be roughly cut in half. As Alternative 3 would employ the same water handling options as Alternative 1, effects would be similar but on a smaller scale.

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	2A	2B	3
Erosional effects from facilities located on soils with high water erosion potential	Increased water erosion and sedimentation due to removal of vegetation, excavation, slope steepening and compaction, especially in clayey soils. Approximately 76,691 acres in the short term and 38,452 acres in the long term would be disturbed on soils with high water erosion potential. Soil loss estimates on these soils range from 3.4 to 18.7 tons/acre/year on bare soil and 0.5 to 2.6 tons/acre/year one year after reclamation.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for water erosion would increase slightly.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for water erosion would increase slightly, but increase would be less than in Alternative 2A.	All disturbance would be roughly cut in half. As Alternative 3 would employ the same water handling options as Alternative 1, effects would be similar but on a smaller scale.
Facility location on slopes greater than 25 percent	No facilities would be located on sloped greater then 25 percent Roads would be located to avoid steep slopes	No facilities would be located on sloped greater then 25 percent Roads would be located to avoid steep slopes	No facilities would be located on sloped greater then 25 percent Roads would be located to avoid steep slopes	No facilities would be located on sloped greater then 25 percent Roads would be located to avoid steep slopes
Effects on soil productivity	Reduction in soil productivity due to removal of vegetation, compaction, changes in salinity, excavation and stockpiling of soil. Approximately 206,777 acres in the short term and 103,800 acres in the long term would be disturbed on soils with high compaction potential, low revegetation potential, high salinity, or on Prime Agricultural soils.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for infiltration would be reduced but soil mixing and compaction would increase slightly.	Nearly the same as Alternative 1, with a very minor increase in disturbed area because of the change in water handling options. Due to the decrease in Surface Discharge and the increase in impoundments, the potential for infiltration would be reduced but soil mixing and compaction would increase slightly. These changes in effects from Alternative 1 would be less than those experienced under Alternative 2A.	All disturbance would be roughly cut in half. As Alternative 3 would employ the same water handling options as Alternative 1, effects would be similar but on a much smaller scale.
Air Quality				
Compliance with Wyoming and federal ambient air quality standards	Yes	Yes	Yes	Yes

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Within range of States' hazardous air pollutant thresholds for maximum 8-hour concentrations	Yes	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
N-Hexane	Yes			
Benzene	Yes			
Toluene	Yes			
Ethylbenzene	Yes			
Xylene	Yes			
Formaldehyde	Above strictest threshold, but well within range			
Compliance with cancer risk threshold:		Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Benzene	Yes			
Formaldehyde	Yes			
Compliance with visibility thresholds in sensitive Class I and Class II areas:				
$\Delta dV > 1.0$ dV	Up to 11.5 days	Up to 10.3 days	Up to 9.5 days	Up to 6.6 days
$\Delta dV > 0.5$ dV	Up to 43.7 days	Up to 41.1 days	Up to 37.9 days	Up to 28.7 days
Vegetation				
Overall long-term vegetation displacement	128, 069 acres	146,963 acres	138,937 acres	52,231 acres
Sagebrush shrublands	40,007 acres	45,943 acres	43,517 acres	15,311 acres
Riparian, wetlands	3,327 acres	7,266 acres	3,402 acres	2,999 acres
Wildlife				
Big Game Species' Important Habitats				
Pronghorn Winter-yearlong range	Approx. 2 percent of this range would be disturbed in the Project Area over the long-term.	Same as Alternative 1	Same as Alternative 1	Approx. 1 percent of this range would be disturbed in the Project Area over the long-term.
White-tailed Deer Winter-yearlong and Yearlong Ranges	Less than 1 percent of both ranges would be disturbed in the Project Area over the long term. 100 percent of the winter-yearlong disturbance would occur in the Middle Powder River sub-watershed.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Mule deer winter-yearlong range	Approximately 1 percent of winter-yearlong range would be disturbed in the Project Area over the long-term — about 50 percent of which would occur in the Upper Powder River sub-watershed.	Less than 1 percent of winter-yearlong range would be disturbed in the Project Area over the long-term — about 50 percent of which would occur in the Upper Powder River sub-watershed.	Approximately 1 percent of winter-yearlong range would be disturbed in the Project Area over the long-term — approximately 58 percent of which would occur in the Upper Powder River sub-watershed.	Less than 1 percent of winter-yearlong range would be disturbed in the Project Area over the long-term 100 percent of which would occur in the Upper Powder River sub-watershed.

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Elk crucial winter range (Fortification Creek)	Approximately 3 percent of crucial winter range would be disturbed in Fortification Creek Management Area.	Approximately 4 percent of crucial winter range would be disturbed in Fortification Creek Management Area.	Same as Alternative 1	Same as Alternative 1
Big Game	Habitat fragmentation may alter big game use of habitats. Human disturbance may deter big game from otherwise suitable habitats to potentially lower quality habitats. Increased human activities may result in increased vehicle collisions, poaching and legal hunting success.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Raptors	Disturbance of ground nesting and prey habitats would occur. Increased human presence may alter raptor activity patterns. New utility poles may provide new perch sites for raptors. New aboveground lines and the potential for increased vehicle/wildlife collisions may increase mortality of local raptors. Habitat disturbance may alter local prey availability.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Sage and Plains Sharp-tailed Grouse	Habitat disturbance may occur in suitable nesting, feeding and brood rearing habitats; increased human activity may affect nesting, breeding, and brood rearing; Increased number of aboveground utility lines may result in increased number of grouse collisions if appropriate mitigation efforts are not implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Waterfowl	Habitat disturbance may be local beneficial or detrimental depending on local hydrological conditions. Benefits may include creation of new habitats and/or improvements of existing habitats. Production waters may also result in the elimination oar degradation of existing habitats. Indirect effects to aquatic plants and invertebrates may occur from exposure to elevated levels of salts and metals in production waters.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Aquatic Life	Surface discharge of produced CBM water in 10 sub-watersheds would potentially increase stream flows, increases in sedimentation, increases of salt concentrations in streams and ponds, and increases of heavy metal concentrations in streams and ponds. The largest amount of surface discharge (62% of 39,367 wells) is proposed under this alternative and would result in the most potential effects to aquatic species.	Surface discharge of produced CBM water in 10 sub-watersheds would potentially increase stream flows, increases in sedimentation, increases of salt concentrations in streams and ponds, and increases of heavy metal concentrations in streams and ponds. 25% of 39,367 wells are proposed to surface discharge under this alternative and would result in less potential effects to aquatic species than Alt. 1 and Alt. 2B.	Surface discharge of produced CBM water in 10 sub-watersheds would potentially increase stream flows, increases in sedimentation, increases of salt concentrations in streams and ponds, and increases of heavy metal concentrations in streams and ponds. 40% of 39,367 wells are proposed to surface dishcarge under this alternative and would result in more potential effects to aquatic species than Alt. 2A and less than Alt. 1.	Surface discharge of produced CBM water in 10 sub-watersheds would potentially increase stream flows, increases in sedimentation, increases of salt concentrations in streams and ponds, and increases of heavy metal concentrations in streams and ponds. The least amount of surface discharge (54% of 15,458 wells) is proposed under this alternative and would result in the smallest amount of potential effects to aquatic species of all Alternatives.
Threatened, Endangered, or Sensitive Species				
Black-tailed prairie dog	Project activities would directly affect individuals and suitable habitats, if appropriate mitigation measures are not implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Preble's meadow jumping mouse	No affects to this species due to assumed lack of occurrence within the Project Area.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Black-footed ferret	No affects to this species due to assumed lack of occurrence within the Project Area.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Bald eagle	Nesting and winter roosting may be affected by increased human activities and local habitat disturbance; and elevated traffic levels in the Project Area may increase eagle/vehicle collisions if mitigation measures are not implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Mountain plover	Human disturbance to suitable nesting and brood rearing habitats may affect this species.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Western boreal toad	No affects to this species due to assumed lack of occurrence within the Project Area.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Cultural Resources				
Total number of cultural resource sites that may be affected (based on known site densities):	3,288	3,604	3,435	1,696
General Distribution of Effects	The greatest anticipated effects would be in the Clear Creek, Upper Powder River, Crazy Woman Creek and Antelope Creek sub-watersheds. It is expected that 430 sites may be historic properties requiring some form of protection or mitigation.	The greatest anticipated effects would be in the Clear Creek, Upper Powder River, Crazy Woman Creek and Antelope Creek sub watersheds. It is expected that 470 sites may be historic properties requiring some form of protection or mitigation. Because of additional water handling facilities along the drainages, this alternative is likely to require more protective or mitigative measures than the other alternatives.	The greatest anticipated effects would be in the Clear Creek, Upper Powder River, Crazy Woman Creek and Antelope Creek sub watersheds. It is expected that 445 sites may be historic properties requiring some form of protection or mitigation.	The greatest anticipated effects would be in the Clear Creek, Upper Powder River, Crazy Woman Creek and Antelope Creek sub watersheds. It is expected that 220 sites may be historic properties requiring some form of protection or mitigation. Some infrastructure or support facilities may occur on federal surface for private development, but federal control over the identification and protection of historic properties would be minimal.
Land Use and Transportation				
Displacement of Rangeland Resources				
Short-term (acres)	229,591	248,485	240,459	108,406
Long-term (acres)	123,201	142,095	134,069	51,396
Additional Vehicle Trips				
Construction and Installation	3,129	3,630	3,366	1,059
Operation and Maintenance	790	790	790	506
Decommissioning & Reclamation	1,206	1,444	1,324	230
Change in average daily traffic relative to Existing Conditions	Over the entire Project Area, the average daily traffic is expected to increase more than 25 percent. The amount of increase on specific roads would vary greatly.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Visual Resources	317 wells, associated roads, and water handling facilities would be constructed on VRM Class II areas. Class II management objectives would be met if mitigation were successfully implemented. Management objectives for 3,939 wells and associated facilities for Class III areas and 4,530 wells and associated facilities for Class IV areas would be met. 437 wells and associated facilities would be constructed on TBNG areas managed with (Scenic Integrity Objectives (SIO) of Low. Desired conditions for SIO would be met, in that facilities can be visible if they are reasonably mitigated to blend and harmonize with natural features.	Wells and roads are same as Alternative 1. Water handling methods would disturb 6,682 additional acres. Class II management objectives would be met if mitigation were successfully implemented.	Wells and roads are same as Alternative 1. Water handling methods would disturb 6,682 additional acres as in Alternative 2A. However, a smaller number of acres would be disturbed by impoundments than Alternative 2A, with a proportionately smaller visual impact. Class II management objectives would be met if mitigation were successfully implemented.	No wells and associated facilities would be constructed on federal leases. Visual impacts from construction and operation would occur on State and private lands.
Recreational Resources	Construction activities would alter the recreational experience through a loss of solitude and the natural setting. After construction, the loss of solitude would be less because of greatly reduced traffic. Installation and operation of facilities would still affect the natural setting of the Project Area for the life of the project. Recreation in special management areas would not be affected. BLM and FS objectives for recreation would be met.	The effect on recreational opportunities from the construction of wells and associated facilities are same as Alternative 1. Water handling methods would disturb an additional 6,682 acres, resulting in a greater loss of solitude and the natural setting.	The effect on recreational opportunities from the construction of wells and associated facilities are same as Alternative 1. Water handling methods would disturb 6,682 additional acres as in Alternative 2A. However, a smaller number of acres would be disturbed by impoundments than Alternative 2A, with a proportionately smaller loss of solitude and the natural setting.	No wells and associated facilities would be constructed on federal leases. No impacts to recreation would occur on BLM lands or the TBNG. Loss of solitude and natural setting could occur on State and private lands.
Socioeconomics				
Effects to Employment	➢ 1,974 CBM workers and 67 non-CBM workers would be required. ➢ Employment would be greatest in first 10 years. ➢ Workers already exist in the community. ➢ Secondary employment would be sustained for a longer period than previously anticipated.	➢ 2,260 CBM workers and 67 non-CBM workers would be required. ➢ Employment would be greatest in first 10 years. ➢ Workers already exist in the community.	➢ 2,112 CBM workers and 67 non-CBM workers are required. ➢ Employment would be greatest in first 10 years. ➢ Workers already exist in the community.	➢ 607 new CBM and 30 non-CBM workers would be required. ➢ Employment would be greatest in first 10 years. ➢ Workers already exist in the community.

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Effects to Wages	➢ Combined annual payroll of the Companies would average an estimated $81.6 million. ➢ Over a 20 period $1.6 billion in personal income would be generated. ➢ Once the project is completed, a reduction in total annual income in the four counties would decline.	➢ Combined annual payroll of the Companies would average an estimated $93 million.	➢ Combined annual payroll of the Companies would average an estimated $87.1 million.	➢ Combined annual payroll of the Companies would average an estimated $25.5 million.
Effects on housing and community infrastructure	➢ Minor employment/population changes are anticipated because most employees are expected to be hired locally. ➢ Rental vacancy rates for 2000 were .2% lower than the average for Wyoming. Additional rental units may be constructed if existing supply of vacant rental units become exhausted. ➢ Due to the minor population influx, there would be minimal impact to water supply, wastewater systems, solid waste disposal, schools, fire protection, and medical facilities. ➢ The Proposed Action would result in increased traffic on roads and therefore road maintenance demands (see transportation).	➢ No change from proposed action ➢ Increase road maintenance due to construction and maintenance of water handling facilities.	Same as Alternative 2A	➢ Population change would not occur and there would be no negative housing or infrastructure effects.

Table 2–42 Summary of Effects, by Alternative

Potential Effect	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Royalties and taxes generated	➢ Federal Royalties = $3.1 billion ➢ State Royalties = $462 million ➢ Sales tax (4%paid to State, 1% paid to counties) = $76.6 million ➢ Severance (paid to State) = $2.4 billion ➢ Ad Valorem (paid to four counties) ➢ Campbell Co.= $1.5 billion ➢ Converse Co.= $32 million ➢ Johnson Co.= $690 million ➢ Sheridan Co.= $443 million	➢ Same royalties as Proposed Action ➢ More taxes would be generated due to the number and cost of water handling facilities.	Same as Alternative 2A	➢ $3.1 billon less in Federal Royalties ➢ $835 million less in Severance Tax ➢ $1.06 billion less in ad valorem tax ➢ Not drilling Federal wells may result in future negative production rates from Federal minerals, due to depletion from drilling on State and private lands.
Water handling cost to industry (all other development costs are constant among Alternatives 1, 2A, and 2B)	Surface Discharge = $954 million Infiltration = $1.05 billion Containment =$226 million LAD= $36 million Injection =$170 million TOTAL =$ 2.4 billion	Surface Discharge = $360 million Infiltration = $2.23 billion Containment = $263 million LAD = $115 million Injection = $184 million TOTAL = $3.1 billion	Surface Discharge = $1.2 billion Infiltration = $1.6 billion Containment = $239 million LAD= $115 million Injection = $184 million TOTAL = 3.3 billion	Surface Discharge = $363 million Infiltration = $478 million Containment = $98 million LAD = $16.7 million Injection = $73 million TOTAL = $1.03 billion
Non-water handling costs (Drilling, O & M, Reclamation)	$5.84 billion	$5.84 billion	$5.84 billion	$2.28 billion
Net Cost of Alternative	$8.28 billion	$8.96 billion	$9.17 billion	$3.31 billion

Chapter 3
Affected Environment

Chapter 3 — Affected Environment

This chapter describes the affected environment for the project alternatives. The affected environment is the portion of the existing environment that could be affected by the project. The information presented here focuses on issues identified through the scoping process and interdisciplinary analyses.

The affected environment varies for each issue. Both the nature of the issue and components of the proposed project and alternatives dictate this variation. The following sections concentrate on providing only the specific environmental information necessary to assess the potential effects of the Proposed Action and alternatives.

Groundwater

Regional Characterization

Groundwater resources are contained in permeable underground aquifers comprised of rock and sediments through which water can flow. Water moves slowly in aquifers in response to the prevailing hydraulic gradient, through tiny open spaces in the rock and sediment. Groundwater is replaced, or recharged, from precipitation that falls directly on the aquifers or by leakage through the beds of streams that intercept aquifers or from adjacent aquifers. Groundwater movement is from recharge areas down the hydraulic gradient to discharge areas.

Aquifer permeability is directly related to the nature and type of porosity of the material comprising the aquifer. Primary porosity is the open space between individual grains or rock clasts. Secondary porosity consists of joints and fractures that form after a rock is consolidated (Whitehead 1996). Primary porosity is the porosity type of unconsolidated-deposit aquifers and consolidated sandstone aquifers in the PRB (Whitehead 1996). Coal aquifers in the PRB contain significant secondary porosity.

Davis (1976) describes groundwater resources as part of a hydrologic system. The components that describe a hydrologic system are the following: aquifer type (or geologic unit); water chemistry; confined (artesian) or unconfined conditions; and groundwater recharge or discharge areas.

Aquifer Types

The groundwater resources of the PRB are described by Whitehead (1996). Groundwater resources that are at or near the land surface within the PRB are contained in unconsolidated Quaternary alluvial or basin fill deposits or in semi-consolidated to consolidated lower Tertiary sandstones and coal beds that are the

uppermost aquifers in the Northern Great Plains aquifer system. Clinker, which is also an aquifer, has formed from some of the lower Tertiary sediments (Heffern and Coates 1999). These Quaternary and Tertiary aquifers are described below in more detail.

Quaternary Alluvial Aquifers

Aquifers in stream-valley alluvium generally occur along rivers and major drainages within the PRB. The groundwater resources contained in alluvial aquifers are described by Whitehead (1996). These unconsolidated deposits of silt, sand, and gravel occur as floodplains, stream terraces, and alluvial fans. Coarser alluvial deposits occur in valleys of the Belle Fourche, Cheyenne, Powder, Tongue, and Little Powder rivers and in the larger tributaries of the Powder and Tongue rivers. Alluvium overlying formations of Tertiary age in the central part of the PRB is mostly fine to medium grained (Hodson et al. 1973).

The thickness of alluvial deposits within the Project Area is mostly less than 50 feet, but may be as much as 100 feet in some valleys near mountains (Hodson et al. 1973). Wells (1982) describes alluvial deposits as commonly 30 feet or less thick, but also reports that deposits 100 feet thick have been measured. Lowry et al (1986) also describe alluvial deposit thickness and water yield from the PRB. The thickest and coarsest-grained alluvium occurs near the Bighorn Mountains along the western margin of the PRB, where saturated horizons are thick and high yields of water are possible. Mostly fine-grained alluvial deposits having a saturated thickness less than 20 feet occur distant from the mountains, resulting in low yields of water.

Northern Great Plains Aquifer System

The Northern Great Plains aquifer system is an extensive sequence of aquifers and confining units arranged in a stack of layers that may be discontinuous locally within the PRB, but which functions regionally as an aquifer system. This system includes the lower Tertiary aquifers that are exposed at the surface in the PRB and underlying, deeply buried regional aquifers that are stacked with intervening confining layers. The deeply buried aquifer systems are comprised of upper Cretaceous sandstones and coals, lower Cretaceous sandstones, upper Paleozoic limestones and dolomites, and lower Paleozoic sandstones, limestones, and dolomites (Whitehead 1996). These deeply buried regional aquifers are stratigraphically below, isolated from, and older than the aquifers that may be affected by CBM development in the PRB and are not described further.

Lower Tertiary Aquifer System

The lower Tertiary aquifer system consists of semi-consolidated to consolidated Oligocene to Paleocene sediments (Whitehead 1996). The Oligocene White River Formation is present in the Project Area only as isolated erosional remnants, such as Pumpkin Buttes in southwestern Campbell County (Lewis and Hotchkiss 1981), and is not described further.

The lower Tertiary aquifers consist of sandstones and coal seams contained in the Eocene Wasatch Formation and the Paleocene Fort Union Formation (Whitehead 1996). Both of these geologic units are continental deposits consisting of sand-

stones, siltstones, claystones, and beds containing lignite and subbituminous coal. Stratigraphically, from youngest to oldest, the Lower Tertiary Aquifer System consists of the Wasatch aquifers, the Fort Union aquifers contained in the Tongue River member of the Fort Union Formation, the Lebo confining layer, and the Tullock aquifer. In locations where these sediments have been altered in place by spontaneous combustion of coal beds, clinker has been formed from these geologic formations (Coates and Heffern 1999).

Clinker plays an important role as an aquifer in the storage and flow of water within the PRB. Rainfall and snowmelt infiltrate rapidly in clinker exposure areas. The stored water is discharged slowly to springs, streams, and aquifers, which helps maintain flow in perennial streams during dry periods (Heffern and Coates 1999). Clinker outcrops cover about 460 square miles of the Project Area and are concentrated in the following areas: along the eastern boundary of the Project Area in the Rochelle Hills, within the Powder River Breaks in the northern portion of the Project Area, within the Tongue River Breaks north of Sheridan, within the Lake De Smet area north of Buffalo, and within the Felix coal outcrop area west of Gillette and northeast of Wright (Heffern and Coates 1997).

Wasatch Aquifers

The Wasatch Formation consists of fine- to coarse-grained, lenticular sandstone interbedded with shale and coal (Hodson et al. 1973). Minor constituents include coarse conglomerates occurring along the western margin of the PRB, carbonaceous shales, and thick coal beds (Seeland 1992). Sandstone layers comprise an estimated one-third of the sequence and are important PRB aquifers. High percentages of sand (from 30 to 50 percent and more) have been documented along a trend paralleling the western margin of the PRB, beginning east of Buffalo and west of the Powder River and continuing toward the southeast (Seeland 1992). Wasatch coal beds are thickest in the central and western portions of the PRB (Seeland 1992). Locally, in the northwest part of the PRB near the Bighorn Mountains, the Wasatch is divided into two conglomeratic members.

The Wasatch Formation is as much as 1,800 feet thick in the southern portions of the PRB (Keefer 1974). Southeast of Buffalo, the maximum preserved thickness of the Wasatch Formation is about 3,000 feet (Seeland 1992).

Fort Union Aquifers

The Fort Union Formation yields water from fine-grained sandstone, jointed coal, and clinker overlying the Lebo confining layer (Zelt et al. 1999). The Fort Union aquifer has a sandstone content ranging from 21 to 91 percent and is hydrologically confined, except near the land surface (Hotchkiss and Levings 1986). The Fort Union Formation is as much as 3,900 feet thick in the southern part of the PRB (Hotchkiss and Levings 1986).

Numerous thick and laterally widespread coal beds occur within the Fort Union Formation and are important PRB aquifers (Lewis and Hotchkiss 1981). The thickness of the Fort Union coal aquifers varies greatly within the PRB. The maximum thickness of a single Fort Union coal seam is less than 25 feet along the western margin of the PRB and in the northern portion of PRB in southeastern Montana. The maximum thickness of a single Fort Union coal seam is more

than 100 feet near Wright and extending west and northwest of Wright, within the central portion of the PRB in Wyoming (Seeland 1992).

Lebo Confining Layer

The lower Paleocene Tullock member of the Fort Union Formation is partially isolated and confined by the overlying Lebo member (Brown 1993). The Lebo confining layer generally retards water movement (Hotchkiss and Levings 1986).

The Lebo confining layer consists predominantly of dark shales containing discontinuous zones of white calcareous banding (paleosol horizons). In the northern portion of the Project Area, the Lebo contains rare beds of gray sandstone as much as 10 feet thick. In the southern PRB some coal beds, a few thicker than two feet, occur within the Lebo and form clinker horizons. The Lebo member ranges in thickness from about 500 feet in the northwestern portions of the PRB to about 1,700 feet in the southwestern portions of the PRB (Brown 1993).

Tullock Aquifer

The lower Paleocene Tullock member of the Fort Union Formation contains alluvial sediments deposited in a continental fluvial environment and is an important PRB aquifer. The Tullock aquifer consists of fine-grained sandstone, sandy siltstone, shale, rare thin limestone, and coal. Sandstone content of the Tullock aquifer ranges from 21 to 88 percent (Hotchkiss and Levings 1986). But, on average, an estimated one-third of the sequence is comprised of channel sandstones. An estimated two-thirds of the sequence is comprised of fine-grained overbank deposits containing thin coal beds (Brown 1993).

Tullock sediments have a maximum thickness of about 370 feet in the north and 1,440 feet in the south (Brown 1993). Tullock sediments are thickest in the southeastern and western portions of the PRB.

Groundwater Chemistry

Water quality in alluvium within the PRB is quite variable. Lowry et al (1986) report concentrations of total dissolved solids (TDS) for alluvial aquifers varying from 106 to 6,610 mg/L, and averaging 2,128 mg/L for 38 samples. Water from surficial deposits that contain less than 600 mg/L TDS may be divided into two chemical types, a calcium magnesium carbonate type and a calcium magnesium sulfate type (Rankl and Lowry 1990). TDS concentrations greater than 600 mg/L generally are due to increased values for sodium and sulfate (Rankl and Lowry 1990). Water in alluvium near the Bighorn Mountains and the Black Hills is better quality than water in alluvium in the central part of the PRB. Water in alluvium in the southwest part of the basin and in the Powder River valley is generally poorer quality than water in alluvium elsewhere in the PRB. No dominant water type is prevalent (Hodson et al. 1973).

The chemical compositions of water in the Powder River and in the river's alluvium are similar (Ringen and Daddow 1990). Water in the Powder River is dominated by sodium and sulfate ions, while water in the river's alluvial deposits is dominated by sodium, calcium, and sulfate ions. The water in the underlying bedrock is dominated by sodium and bicarbonate ions. The quality of water in the

alluvium limits its use as a water supply, being unacceptable for drinking water, acceptable for most livestock, and marginal for irrigation or industrial use.

The quality of water in the Wasatch aquifer within the PRB is quite variable. Lowry et al. (1986) report TDS concentrations for Wasatch aquifers varying from 227 to 8,200 mg/L, and averaging 1,298 mg/L for 191 samples. Sodium sulfate and sodium bicarbonate are the dominant water types (Hodson et al. 1973). Dahl and Hagmaier (1976) describe groundwater chemistry changes along the regional flow path in the vicinity of the Highland uranium deposits in the southern PRB. The chemistry changes from a sulfate-rich groundwater with minor bicarbonate in the recharge area southwest of the Highland area to a bicarbonate-rich groundwater in the discharge area northeast of the uranium deposits. This change in chemistry is attributable to sulfate reduction, which decreases sulfate concentration and increases bicarbonate concentration.

Rankl and Lowry (1990) describe the change in chemical quality of water in the Lower Tertiary aquifer system with depth in the PRB, obtained through an analysis of USGS data from water wells and springs. There is a decrease in calcium, magnesium, and sulfate and an increase in bicarbonate down to a depth of about 500 feet; however, deeper than 500 feet the concentration of dissolved constituents is relatively uniform.

Hodson et al (1973) provide an overview of water quality in the Fort Union aquifers. Concentrations of TDS range from about 200 to more than 3,000 mg/L, but commonly range between 500 and 1,500 mg/L. Water type is mostly sodium bicarbonate and, to a lesser extent, sodium sulfate. The dominant chemical reactions that control the chemistry of Fort Union groundwater are cation-exchange softening and sulfate reduction (Rankl and Lowry 1990). The water from deep wells is soft, meaning sodium plus potassium exceeds calcium plus magnesium, and many water samples contain carbonate as well as bicarbonate (Rankl and Lowry 1990).

Davis (1976) describes the chemistry of groundwater of the Fort Union aquifer within the eastern PRB. Along the coal outcrop, the water generally is calcium-magnesium sulfate type, changing to sodium bicarbonate type westward where confined aquifer conditions exist. There is a relationship between the confined and unconfined state of the aquifer and the chemical quality of water within the aquifer. As a general rule, waters within unconfined portions of the coal aquifer are calcium-magnesium-sulfate type and those within confined portions of the aquifer are sodium bicarbonate type.

CBM development within the PRB has generated detailed water quality information for the coal zone aquifers within the Fort Union aquifer (Rice et al. 2000, Energy Labs 2001, Flores et al. 2001). Table 3–1 summarizes basinwide CBM produced water composition for the PRB.

The quality of CBM produced water in the Project Area is summarized in Table 3–2. CBM produced waters in the Project Area have mean TDS concentrations that range from 770 mg/L in the Upper Belle Fourche River sub-watershed, to about 3,000 mg/L in the Middle Powder River sub-watershed. These CBM pro-

duced waters are typically slightly alkaline, hard sodium bicarbonate, and sodium sulfate type waters.

Table 3–1 Powder River Basin Produced Water Composition

Parameter (units)	Range	Average	DWS[1]
pH (standard units)	6.8-7.6	7.2	6.5-8.5
TDS (mg/L)	300-1,900	740	500
Chloride (mg/L)	5.3-64	16	250
Sulfate (mg/L)	0-17	3.3	250
Bicarbonate (mg/L)	330-2,300	850	---[2]
Calcium (mg/L)	9.1-69	35	---[2]
Potassium (mg/L)	4.1-19	9.3	---[2]
Magnesium (mg/L)	3.4-46	17	---[2]
Sodium (mg/L)	110-710	240	---[2]

Source: Flores et al. 2001

Notes:

1 DWS means national Drinking Water Standard

2 --- means no recommended values

Concentrations of TDS within clinker varies widely from under 500 mg/L to more than 7,000 mg/L. Water in clinker from recharge areas near the burn line tends to be a calcium sulfate type and water in clinker from discharge areas tends to be a sodium bicarbonate type similar to water in the coal. Ash residue at the base of the clinker may contribute to high TDS concentrations (Heffern and Coates 1999).

Rankl and Lowry (1990) provide an overview of water chemistry for water wells in the PRB. Water wells, excluding municipal water supply wells, generally are shallow (less than 500 feet deep) and generally yield calcium sulfate or calcium sodium sulfate waters. Deep wells generally yield sodium bicarbonate type water.

Confined (Artesian) vs. Unconfined Conditions

The groundwater resources contained in alluvial aquifers are under unconfined or water table conditions (Whitehead 1996). Normally, clinker is an unconfined aquifer (Heffern and Coates 1999). Groundwater resources contained in the Wasatch aquifers occur under partially confined conditions (Whitehead 1996).

The Fort Union coal zone aquifers are hydrologically confined, except near the land surface (Hotchkiss and Levings 1986). The underlying Lebo confining layer generally retards water movement (Hotchkiss and Levings 1986). The lower Paleocene Tullock member of the Fort Union Formation is partially isolated and confined by the overlying Lebo member (Brown 1993). The Tullock aquifer is hydrologically confined, except near outcrop areas (Hotchkiss and Levings 1986).

Table 3–2 CBM Produced Water Quality in the Powder River Basin

Drainage		Constituent															
		Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)	Specific Conductance (umhos/ centimeters)	Sodium Adsorption Ratio	pH (Std. Units)	Arsenic (µg/L)	Barium (µg/L)	Iron (µg/L)	Manganese (µg/L)	Selenium (µg/L)
Upper Powder River	Minimum	7	5	18	4	51	2	U[1]	214	342	0.1	6.8	U	U	30	U	U
	Mean	120	89	497	13	1,065	19	548	1,884	2,428	13.5	7.7	1.78	422	76.7	156	0.052
	Maximum	646	528	1,470	35	3,080	152	4,260	7,210	7,460	40	8.6	23.4	1,400	1,080	8,500	5
	Count	107	107	108	72	76	112	106	124	221	146	124	177	9	135	134	96
Middle Powder River	Minimum	190	121	184	9	427	6	1,360	2,300	2,700	2.1	7.6	0.6	U	30	50	U
	Mean	270	199	325	11	597	21	1,745	2,977	3,423	3.7	7.6	0.9	U	42.9	601	0.83
	Maximum	424	265	539	14	934	37	2,410	3,830	4,030	7.2	7.6	1.3	U	100	2,230	5
	Count	12	12	12	12	12	12	12	12	12	12	1	6	1	7	7	6
Little Powder River	Minimum	8	4	78	3	220	5	U	495	616	2.4	6.7	U	U	30	U	U
	Mean	82	88	393	10	792	18	90	1,170	2048	8.9	7.1	0.62	1,014	414	174	0.08
	Maximum	428	1,020	2,080	15	1,370	740	5,660	8,810	12,740	14.5	8.4	16.9	1,400	9,600	10,100	1
	Count	133	133	134	19	30	162	128	147	321	159	196	167	7	182	172	62
Antelope Creek	Minimum	48	14	223	NA[2]	NA	18	2	698	1,130	7.3	NA	0.59	NA	NA	NA	U
	Mean	48	14	223	NA	NA	18	2	698	1,130	7.3	NA	0.59	NA	NA	NA	U
	Maximum	48	14	223	NA	NA	18	2	698	1,130	7.3	NA	0.59	NA	NA	NA	U
	Count	1	1	1	0	0	1	1	1	1	1	0	1	0	0	0	1
Upper Cheyenne River	Minimum	11	5	111	4	NA	3	U	323	542	6.2	6.5	0.5	NA	390	U	U
	Mean	14	7	128	5	NA	8	2	402	787	7.0	7.0	1.65	NA	390	5	U
	Maximum	18	9	143	6	NA	10	4	677	1,160	8.5	8.1	3.3	NA	390	10	U
	Count	8	8	8	8	0	14	8	9	58	9	13	23	0	1	2	9
Upper Belle Fourche River	Minimum	10	4	131	3	330	1	U	2	1	2.9	6.7	U	U	30	U	U
	Mean	37	16	264	8	834	14	18	770	1,202	9.1	7.1	0.51	300	617	43.2	0.13
	Maximum	134	93	420	20	1,400	36	1,080	1,790	2,460	15.5	8.4	5.4	800	7,750	370	8
	Count	130	133	126	112	80	217	200	189	840	131	163	284	8	121	124	150

Notes:
1. U = Undetected.
2. NA = Not Analyzed

Source: Energy Labs 2001

Groundwater Flow Systems (Groundwater Recharge vs. Groundwater Discharge Areas)

Groundwater discharge from the Project Area is principally by groundwater outflow; by loss to gaining streams, springs, and seeps; by evapotranspiration; and by well pumpage (Hotchkiss and Levings 1986). The regional pattern of groundwater flow is complicated by lenticular (discontinuous) beds and local differences in hydraulic conductivity (how the water moves through the aquifer). Water in the lower Tertiary aquifers generally moves northward from recharge areas at higher elevations toward discharge areas at lower elevations (Whitehead 1996). The regional trend of movement changes locally where the aquifers discharge water to large streams, primarily within the lower portions of the Powder River drainage in the Project Area.

Rankl and Lowry (1990) describe groundwater flow systems in the PRB. Northward regional groundwater flow is expected in the PRB from potentiometric data that relate the position of the underground aquifers with respect to the topography of the land surface and streams. Groundwater (potentiometric surface) data suggest most streams in the PRB should receive base flow (groundwater discharge) from a regional groundwater system. However, streamflow records do not support this conclusion. The locations of streams having base flows and the period of time that base flows occur indicate base flows are discharged to surface waters from local groundwater systems rather than a regional system. Additionally, groundwater discharge areas have not been identified in the northern part of the Project Area on the basis of chemistry of springs and shallow wells. The chemical quality of shallow groundwater in the northern part of the PRB is affected more by local conditions than by regional flow.

Rankl and Lowry (1990) analyzed data from streamflow gaging stations on streams that originate in the area underlain by the Lower Tertiary Aquifer System and have five or more years of record. Base flow occurring during the period of greatest precipitation, but not after the growing season, indicates that base flow is from a local system dependent upon precipitation for each year's discharge. Much of the groundwater discharge from bedrock aquifers is above stream level and is lost due to evapotranspiration, resulting in no measurable contribution to base flow. Within the Project Area, only the Little Powder River had measurable groundwater contribution (1 cfs) during the non-growing season. Groundwater contribution of less than 1 cfs was indicated for the Belle Fourche River and Dead Horse Creek (near Buffalo). No groundwater contribution was indicated for Black Thunder Creek or the Cheyenne River.

The major sources of groundwater recharge are infiltration of water from precipitation, streamflow on areas of outcrops, or losing streams, including some perennial stream reaches along the front of the Bighorn Mountains. Regional groundwater flow simulations performed by Hotchkiss and Levings (1986) indicate recharge by direct precipitation accounted for about 30 percent of the total recharge.

Heffern and Coates (1999) describe the role of clinker in the storage and flow of water in the PRB. Normally, clinker outcrop areas are highly permeable, allow-

ing rapid infltration of rainfall and snowmelt and then slowly discharging the stored water to springs, streams, and aquifers. This stored water helps maintain flow in perennial streams during dry periods.

Davis (1976) describes groundwater recharge and discharge within the eastern PRB. Most of the eastern PRB is a recharge area for the groundwater system below the Wasatch Formation. There are no perennial streams in the vicinity of the coal outcrop. The scoria (clinker) along the coal outcrop appears to be a very important area of recharge to the coal aquifers. Stream valleys provide primary recharge areas for the Wasatch Formation.

Within the Project Area, the Powder River loses water to the alluvium in the reach from Sussex to the State line, with the loss attributed to evapotranspiration from the alluvium (Rankl and Lowry 1990). This type of system is common in the Project Area. The average loss of flow per valley mile in the Project Area along the Powder River below Arvada was 0.31 cfs during late fall and early winter, as reported by Rankl and Lowry (1990).

Ringen and Daddow (1990) describe the hydrology of the generally fine-grained alluvial deposits occurring along the Powder River, within and near the Project Area. Alluvium ranges from 4 to 45 feet thick, but commonly is 10 to 30 feet thick and about one-half mile wide. The alluvium has direct hydraulic connection to the river. Water in the alluvium is supplied primarily by the river, which goes dry periodically. Seepage from the Powder River is stored in the alluvium during periods of high streamflow and is discharged back to some reaches of the river during low flow. Flow-duration curves and stream gain-loss analyses indicate that groundwater discharge, or irrigation return flow, or both contribute to streamflow during low flow conditions at Sussex, but not at Arvada or downstream from Arvada, where the discharge is lost through evapotranspiration.

Water Yield

Water yields of about five to 1,000 gpm from PRB alluvial aquifers have been reported (Hodson et al. 1973, Lewis and Hotchkiss 1981). Zelt et al (1999) report a water yield of 5 to 100 gpm for alluvium. Water yield from PRB alluvial deposits is constrained in areas where the alluvium is fine grained (Rankl and Lowry 1990).

Water yields from Wasatch/Fort Union sandstone, coal, or clinker deposits have been described by Lewis and Hotchkiss (1981). In the southern part of the PRB, yields as great as 500 gpm may be possible from sandstone or clinker deposits, with proper well construction techniques. Well yields of 10 to 50 gpm have been measured. Zelt et al. (1999) report a water yield of about 3 to 50 gpm in the northern PRB, becoming greater moving southward in the PRB, with about 500 gpm or more possible in the southern PRB. Water yields from the Fort Union aquifer reported by Zelt et al. (1999) are about 3 to 160 gpm. Hodson et al. (1973) report a maximum water yield of about 150 gpm.

Static levels of water in water wells and water yields from wells have been affected by coal mining and CBM development in the PRB. Meyer (1999) summarizes the drawdown of hydrostatic head in the Wyodak Anderson coal zone from

1980 to 1998. Existing drawdowns of the hydrostatic head in wells are interpreted to be 100 to 300 feet in extensively developed areas. However, water levels can vary considerably over short distances due to changes in geologic conditions. The greatest existing drawdowns are interpreted to occur in the following four townships: T.47N. R.72W.; T.48N.R.72W.; T.47N. R.73W.; and T.48N. R.73W. Figure 3–1 shows existing drawdown within the Project Area.

CBM development within the PRB has generated detailed water yield information for the coal zones within the Fort Union aquifer. Water production data acquired from CBM wells in the PRB are summarized by sub-watershed area (hydrologic unit) for 2000 in Table 3–3.

Table 3–3 2000 Water Production from CBM Wells for the Powder River Basin, WY

Sub-watershed	Pre-2002 CBM Wells[1]	Water Production (barrels)
Upper Tongue River	815	6,590,722
Upper Powder River	2,808	42,736,739
Crazy Woman Creek	150	28,706
Clear Creek	389	43,877
Middle Powder River	727	7,563,589
Little Powder	1,813	66,667,649
Antelope Creek	253	1,769,502
Upper Cheyenne River	454	48,491,981
Upper Belle Fourche River	4,662	200,409,537
Middle North Platte River	6	0
Total	12,077	374,302,302[2]

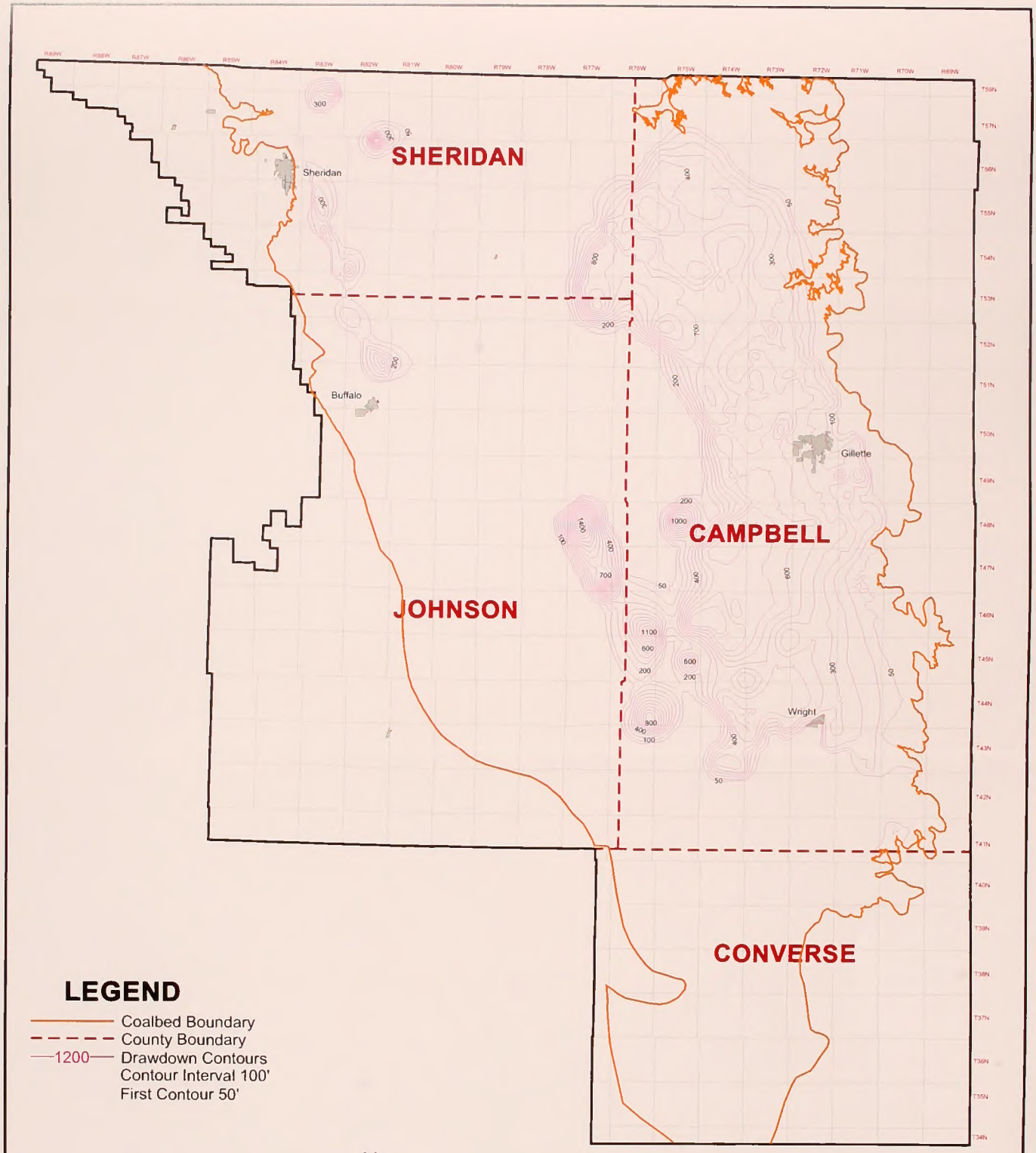
Source: WOGCC 2001b.
Notes:
1. Pre-2002 wells include all wells drilled or projected for completion by 2002 (not all are producing).
2. The total varies slightly from the non-GIS 2000 Production Statistics posted on WOGCC's website (374,787,920).

Water yield from the Lebo confining layer has been described by Lewis and Hotchkiss (1981). Wells penetrating a sufficient saturated thickness of lenticular channel deposits may yield as much as 10 gpm.

Water yield from the Tullock aquifer has been described by Lewis and Hotchkiss (1981). Fine-grained sandstones and jointed coal beds may yield as much as 40 gpm, but yields of 15 gpm are more common. Where the aquifer is confined, wells generally flow less than 10 gpm.

Groundwater Use

Rankl and Lowry (1990) describe water wells and groundwater use in the PRB. Water wells generally are less than 500 feet deep and principally support livestock and domestic uses. These shallow wells generally produce calcium sulfate or calcium sodium sulfate waters. Yields from shallow wells completed in sandstone aquifers generally are about 20 gpm. Deep wells yield larger quantities of water that generally is a sodium bicarbonate type. Water from alluvium has not

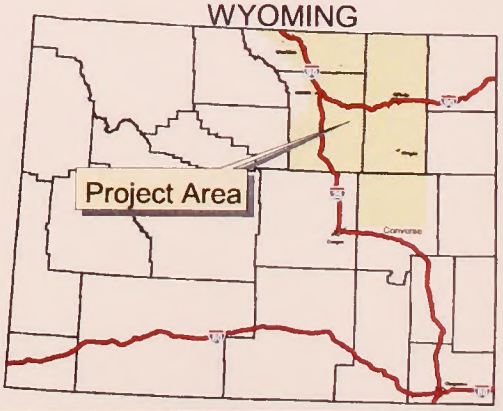


LEGEND

- Coalbed Boundary
- County Boundary
- 1200 Drawdown Contours
  Contour Interval 100'
  First Contour 50'

N

13 0 13 26 39 Miles



POWDER RIVER BASIN OIL/GAS EIS PROJECT	
FIGURE 3-1 *INTERPRETED 2000 WATER WELL DRAWDOWN CONTOURS*	
ANALYSIS AREA: CAMPBELL, CONVERSE, JOHNSON & SHERIDAN COUNTIES, WYOMING	
Date: 11/17/01	Drawing File: 1011 Drawdown.dwg
Scale: As Noted	Drawn By: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc. (2001d)



been developed extensively because the underlying Tertiary aquifers contain better quality groundwater and yield higher volumes of water.

Permitted, non-CBM groundwater withdrawals are summarized for the Project Area in Table 3–4. Almost 25 percent of the nearly 27,000 permitted, non-CBM water wells in the PRB are used for domestic purposes. About 1.5 percent of the permitted wells provide for irrigation or municipal uses. The remaining nearly 75 percent of the water wells in the Project Area are used for stock watering and other purposes.

Table 3–4 WSEO-Permitted Non-CBM Wells in the Project Area

Well Type	Formation Name[1]	Number of Wells
Domestic	Fort Union	2,218
	Wasatch	3,173
	Unknown	1,192
	Total	6,583
Irrigation	Fort Union	45
	Wasatch	92
	Unknown	117
	Total	254
Municipal	Fort Union	50
	Wasatch	42
	Unknown	43
	Total	135
Other	Fort Union	6,771
	Wasatch	9,115
	Unknown	4,088
	Total	19,974
Total		26,946

Note:
1. Applied Hydrology, Inc. (Bedard 2001) associated formation names with completed wells wherever well depths were available from WSEO data.

Sources: Bedard 2001, WSEO 2001

An estimated 46 percent of the permitted non-CBM water wells in the Project Area are completed in the Wasatch Formation. An estimated 34 percent of the permitted non-CBM water wells are completed in the Fort Union Formation. No formation name is available for the remaining almost 20 percent of the wells.

Figure 3–2 shows the relative numbers of permitted water wells and existing CBM wells located within the Project Area. The Upper Belle Fourche River and the Upper Tongue River sub-watersheds contain the largest number of permitted non-CBM water wells, 23 percent and 16 percent of the totals for the Project Area, respectively.

Surface Water

Regional Characterization

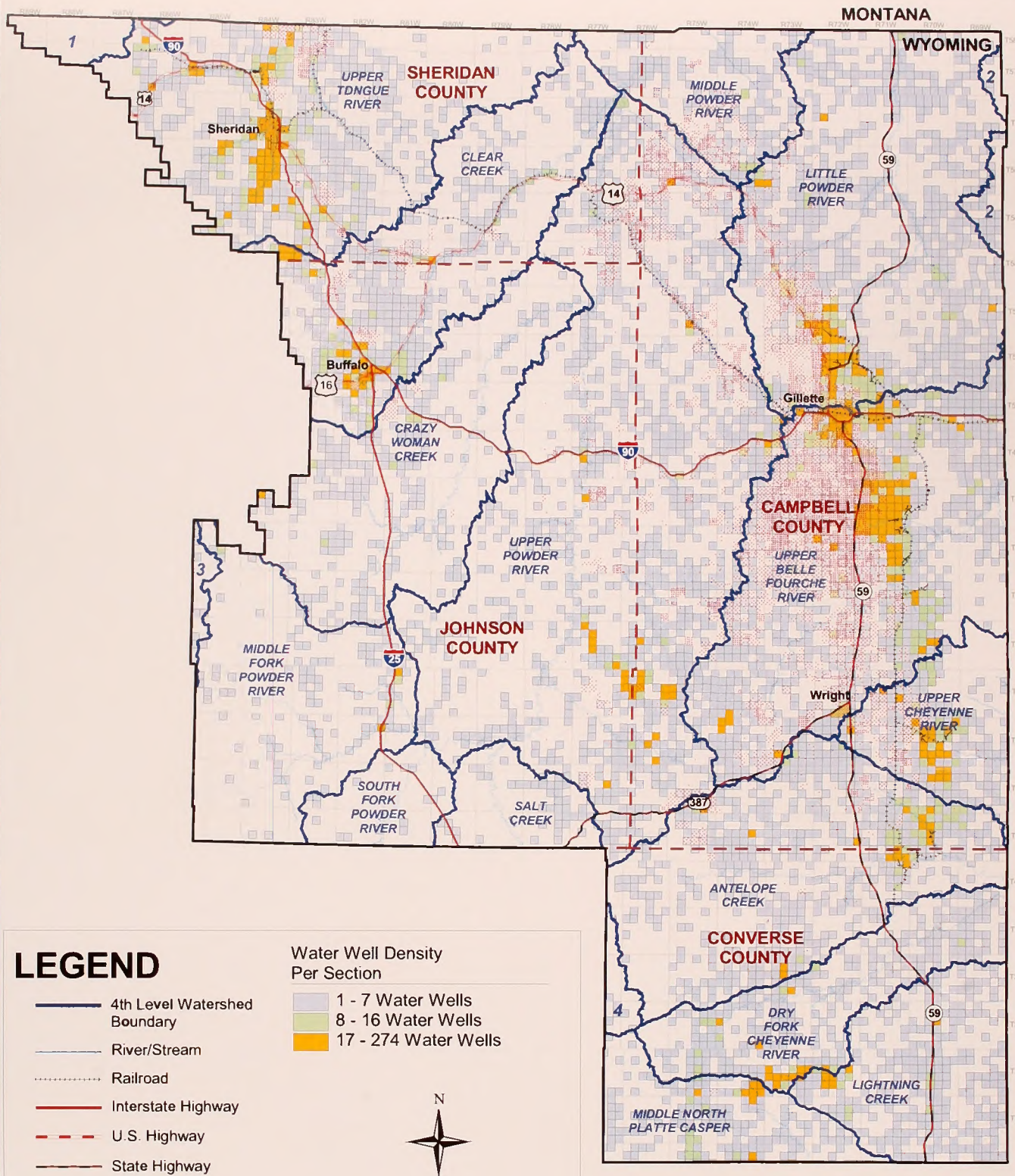
The Project Area is contained within several large river basins, which are headwaters to the much larger Missouri River Basin. Major rivers in the Project Area include the Powder River, Little Powder River, Tongue River, Belle Fourche River, and Cheyenne River. The major river valleys have wide flat floors and broad floodplains. Tributaries in the Project Area are incised and drain areas of isolated, flat-topped, clinker-covered buttes and mesas, 100 to 500 feet above the valley floor. Flow in the Project Area is generally towards the northeast. Perennial streams generally originate in the mountainous areas as a result of significant annual precipitation and geologic conditions that foster groundwater discharge.

The Project Area is semi-arid with average annual precipitation ranging from 12 to 16 inches. Normal annual precipitation increases generally eastward in the downstream direction (Taylor 1978). The majority of annual runoff in streams draining mountainous areas occurs during spring and early summer as a result of snowmelt. Nearly one half of the average annual precipitation occurs during the months of April, May, and June (Rankl and Lowry 1990). Streamflow generally peaks during June; however, this varies from year-to year depending on both local weather conditions and physical features of individual basins. Late summer, fall, and winter flows are largely the result of ground-water inflows. Minimum streamflows occur generally from January through March (Lowham 1988).

Surface water quality in the Project Area is generally adequate to support designated uses. Surface waters in the Project Area are typically alkaline, with moderate to high levels of hardness. These waters vary from a calcium bicarbonate type water in the mountain streams, to a sodium sulfate type water in the lowlands. Surface water quality in the Project Area is affected by depletions and return flows from irrigation. Surface water withdrawals in the Project Area are used to support agricultural, domestic, and stock water uses. Irrigation use accounts for about 98 percent of the surface water withdrawals in the Project Area.

Characteristics of River Basins and Surface Drainage Systems

The Project Area is divided into 18 sub-watersheds. The sub-watersheds in the Project Area comprise two distinct hydrologic regions: the mountainous region, where snowmelt has a dominant influence on streamflows and the plains region, where runoff from convective storms has a significant influence on peak flows (Lowham 1988). In the mountainous region, headwaters of the streams are situated in mountains and foothills, at elevations ranging from 6,000 to 13,000 feet above mean sea level (msl). Annual precipitation ranges from 14 to 25 inches, mostly from snow (Lindner-Lunsford et al. 1992). Streams are cascading, with relatively steep slopes. Concentrations of suspended sediments and dissolved solids are lower in mountain streams overlying older geological formations, and increase significantly as the streams flow toward lower elevations. Streamflows originating in the mountainous region are perennial. Annual runoff typically exceeds 0.3 cubic feet per square mile (Hodson et al. 1973).



LEGEND

- 4th Level Watershed Boundary
- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary
- Existing CBM Well

Water Well Density Per Section

- 1 - 7 Water Wells
- 8 - 16 Water Wells
- 17 - 274 Water Wells

N

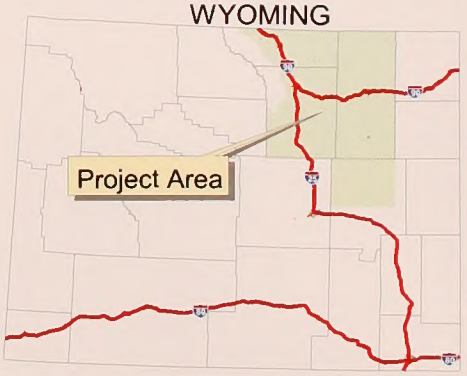
Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers

Sub-Watersheds

1–Little Bighorn River
2–Little Missouri River
3–North Fork Powder River
4–Salt Creek



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 3-2 WATER WELL DENSITY & EXISTING CBM WELLS	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_v1\data\maps.apr Layout–Groundwater CBM Wells
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management–Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13


LEGEND

In the plains region, streams are situated in plains, tablelands, badlands, and open high hills, at elevations ranging from 3,000 to 6,000 feet above msl. Annual precipitation ranges from 10 to 14 inches (Lindner-Lunsford et al. 1992). Streams are meandering, with relatively flat slopes. Concentrations of suspended sediments and dissolved solids are higher than in the mountain streams, due to contact with younger geologic formations and disturbance from human activities in the lower elevations. Streams originating in the plains and desert areas generally are ephemeral, flowing mainly in direct response to rainstorms and snowmelt (Lowham 1988). Annual runoff is generally less than 0.05 cubic feet per square mile (Hodson et al. 1973).

Within these two regions, each sub-watershed in the Project Area has a unique combination of water quantity, quality, and existing water use.

Surface Water Quantity

Major contributions to streamflows in the Project Area include direct precipitation, surface runoff, and releases from surface reservoirs. Evaporation, evapotranspiration, and infiltration cause decreases in streamflow. These components are described below.

For the purposes of this discussion, surface water flow is expressed in cfs. The water produced from wells is expressed in gpm. One cfs is equivalent to 448.83 gpm. Large flows or volumes of water are expressed as acre-feet. One acre-foot is equivalent to 43,560 cubic feet, or 325,851 gallons. Large volumes of produced water also are expressed as barrels (Bbls) or thousand barrel units (MBbls). There are 42 gallons in one barrel.

Natural Streamflow

Streamflow characteristics depend upon the specific features unique to each drainage basin. These features include geology, topography, vegetative cover, size, and climate. Most of the streams in the Project Area are ephemeral, flowing only in response to snowmelt or precipitation events. The major perennial streams and tributaries in the Project Area experience their highest flows during May, June, and July. Peak flows are the result of melting snow that accumulates in the higher elevations from October to April. The lowest flows occur during the winter months.

Mean annual flow data have been compiled from selected USGS stream gaging stations to provide a perspective of perennial stream flow within the Project Area. This information is summarized in Table 3–5. Flows range from minimal in the Dry Fork of the Cheyenne River, to 1,282 cfs in the Middle North Platte River. For the period of record 1931 to 1999, the Upper Powder River at Arvada averaged an annual flow of 281 cfs. The Upper Belle Fourche River below Moorcroft averaged an annual flow of 24.6 cfs for the period of record 1944 to 1999. The highest mean annual flow of 1,282 cfs was measured in the Middle North Platte River near Alcova for the period of record 1905 to 1998. Flows in the Project Area are influenced by irrigation diversions and releases from storage reservoirs.

Table 3–5 Annual Flow Statistics at Selected USGS Gaging Stations in the Powder River Basin

Sub-Watershed	Drainage Area (mi^2)	Station Location	Station ID	Mean (cfs)	Min (cfs)	Max (cfs)	Period of Record
Little Bighorn River	428	L Bighorn R bl Pass Cr nr Wyola, MT	06290500	204	95	390	1940-1999
Upper Tongue River	1,477	Tongue R @ State Line nr Decker, MT	06306300	463	209	872	1961-1999
Middle Fork Powder River	45.2	Middle Fork Powder R nr Barnum, WY	06309200	30.6	13.2	50.5	1961-1999
North Fork Powder River	803	Nowood R nr Ten Sleep, WY	06270000	112	57.1	258	1953-1955 1973-1991
Upper Powder River	6,050	Powder R at Arvada, WY	06317000	281	90.4	744	1931-1999
South Fork Powder River	1,150	South Fork Power R nr Kaycee, WY	06313000	37.2	14.4	119	1939-1979
Salt Creek	769	Salt Creek nr Sussex, WY	06313400	44.4	22.8	81.9	1977-1992
Crazy Woman Creek	945	Crazy Woman Creek at Upper Sta, nr Arvada, WY	06316400	56.7	11.7	125	1964-1980
Clear Creek	1,110	Clear Creek nr Arvada, WY	06324000	181	49	404	1916-1981
Middle Powder River	8,088	Powder R at Moorhead, MT	06324500	465	136	1,093	1929-2000
Little Powder River	1,235	L Powder R Ab Dry C nr Weston, WY	06324970	22.9	1.5	125	1972-1999
Little Missouri River	904	L Missouri R nr Alzada, MT	06334000	61.8	3.0	323	1913-1968
Antelope Creek	1,030	Antelope C nr Teckla, WY	06364700	12.6	2.0	28.7	1978-1980
Dry Fork Cheyenne River	128	Dry Fork Cheyenne R nr Bill, WY	06365300	1.0	0.2	3.5	1977-1986
Upper Cheyenne River	5,270	Cheyenne River nr Riverview, WY	06386500	60	6	283	1949-1973
Lightning Creek	2,070	Lance Creek nr Riverview, WY	06386000	26.5	2.5	87.4	1949-1982
Upper Belle Fourche River	1,690	Belle Fourche R bl Moorcroft, WY	06426500	24.6	1.1	135	1944-1999
Middle North Platte River	10,812	North Platte R at Alcova, WY	06642000	1,282	662	2,604	1905-1998

Source: USGS 2001c

Peak Flow/Stormwater Flow

Peak flows in the Project Area occurred in May 1978, when the region experienced a flood of one percent probability, or a flood that occurs once every 100 years (Parrett et al. 1984). Peak flows during this event in the Little Powder River, Middle Powder River, and Upper Belle Fourche River measured 5,300 cfs, 33,000 cfs, and 15,300 cfs, respectively.

Stormflows have been estimated for each sub-watershed in the Project Area using the basin characteristics methodology as outlined by Lowham (1988). This information is summarized in Table 3–6.

Evaporation

Evaporation losses in the Project Area occur from water surfaces, such as reservoirs and stream channels. Throughout the Project Area, annual lake evaporation averages from 39 to 45 inches, greatly exceeding annual precipitation (Whitehead 1996). Pan evaporation rates in the Project Area are as much as 60 inches per year. Evaporation data are typically only collected during periods of warm weather, or seasonally. The highest evaporation rates generally occur during the summer months of June, July, and August and typically decrease during the winter months. Evaporation is large during periods of intense solar radiation, low relative humidity, and rapid wind movement (Taylor 1978).

Evapotranspiration (ET) measurements include evaporation from water and soil surfaces and the transpiration from plants. Lowry et al (1986) describe ET rates highest during the month of July, but still significant over the fall months due to warm soil temperatures. Rankl and Lowry (1990) compare ET rates with the growing season for vegetation. During the growing season, April through September, ET is greatest. From October through March, which approximates the dormant period of vegetation, ET rates are lower. Miller (1981) calculated poten-

tial ET rates for the Powder River Basin in southeastern Montana, which range from 24 to 41 inches per year. This is considerably greater than the average annual precipitation of 16 inches for the area, except for extremely wet years.

Table 3–6 Predicted Stormflows by Sub-watershed within the Powder River Basin

		Flow (cfs)					
Sub-Watershed	Watershed Area (mi^2)	2-year 24-hour	5-year 24- hour	10-year 24-hour	25-year 24- hour	50-year 24-hour	100-year 24-hour
Little Bighorn River	1,275	3,008	5,042	6,678	9,486	12,355	14,851
Upper Tongue River	2,547	4,037	6,807	8,937	12,496	16,022	18,910
Middle Fork Powder River	992	2,309	3,904	5,050	6,931	8,686	10,164
North Fork Powder River	1,994	4,432	7,158	9,074	12,177	15,116	17,383
Upper Powder River	2,497	3,560	6,140	8,185	11,651	15,128	18,065
South Fork Powder River	1,219	2,300	4,018	5,318	7,475	9,538	11,299
Salt Creek	807	1,476	2,651	3,577	5,134	6,637	7,987
Crazy Woman Creek	962	1,787	3,155	4,217	5,992	7,704	9,207
Clear Creek	1,149	2,384	4,020	5,243	7,257	9,182	10,800
Middle Powder River	1,067	1,712	2,915	3,899	5,604	7,340	8,935
Little Powder River	2,033	3,007	5,042	6,678	9,486	12,355	14,851
Little Missouri River	3,440	4,714	7,610	9,929	13,938	18,141	21,706
Antelope Creek	1,051	1,959	3,398	4,514	6,379	8,187	9,762
Dry Fork Cheyenne River	492	917	1,694	2,322	3,391	4,423	5,393
Upper Cheyenne River	1,435	2,269	3,937	5,272	7,541	9,804	11,793
Lightning Creek	1,014	1,810	3,156	4,217	6,006	7,757	9,306
Upper Belle Fourche River	2,940	5,311	8,347	10,621	14,401	18,183	21,151
Middle North Platte River	3,490	5,959	9,966	12,864	17,621	22,210	25,748

Source: Lowham 1988

Infiltration

Infiltration and seepage losses into underlying alluvium and geologic substrates occur along stream channels and reservoirs in the Project Area.

Meyer (2000) analyzed CBM water production and streamflow data for a portion of the Belle Fourche River basin during the months of May through September. The analysis indicated that little or none of the water discharged as a result of CBM operations reached the stream gaging locations. During periods of little or no precipitation, conveyance losses due to ET and infiltration may be greater than 90 percent (Meyer 2000). Similar trends were noted by Meyer in the Little Powder River drainage. Meyer concludes that "water production volumes are not as great as estimated in the Wyodak EIS (BLM 1999c) and streamflow conveyance losses have been significantly greater than predicted."

AHA conducted conveyance loss studies on representative drainages receiving CBM produced water discharges in the Project Area. These studies were conducted during October 2000 when ET rates are typically minimal and conveyance losses from stream channels and reservoirs are primarily due to infiltration.

Results indicated infiltration of about 80 percent, on average, with infiltration as high as 99 percent in selected drainages (AHA 2001b).

CBM Produced Water

Produced water from CBM wells is currently gathered and discharged to the surface at outfall locations permitted by the WDEQ after the issuance of a National Pollutant Discharge Elimination System (NPDES) permit.

In portions of the Project Area, produced water from existing CBM development is supplementing stream flows or wetting otherwise dry channels year-round for some stream channel length or segment below the surface discharge points.

Discharge Outfalls

A search of the State of Wyoming's NPDES database reveals 696 existing point source discharge permits within the Project Area, corresponding to 3,975 permitted outfalls (WDEQ 2001). Permitted outfalls from CBM facilities comprise 94 percent of the total, followed by coal mining facilities (4 percent), and oil treater facilities (1.5 percent). The permitted outfalls for CBM facilities within the Project Area are summarized on Table 3–7, and illustrated on Figure 3–3. Almost 50 percent of the CBM outfalls are located within the Upper Belle Fourche River sub-watershed. The majority of the remaining CBM outfalls are distributed in the Upper Powder River sub-watershed (21 percent), and the Little Powder River sub-watershed (14 percent).

Table 3–7 Permitted Outfalls for CBM Discharges in the Powder River Basin

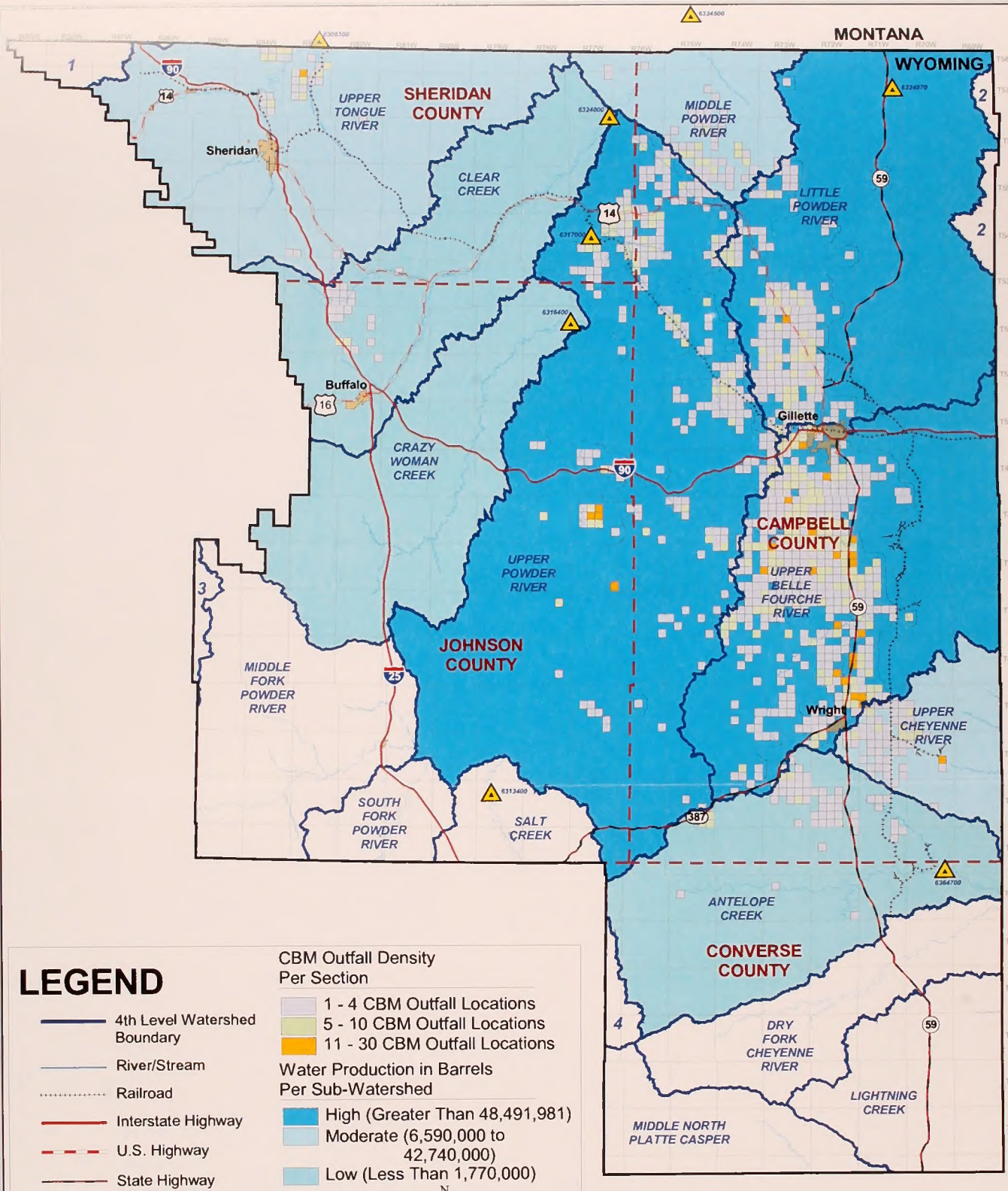
Sub-watershed	# CBM Discharge Permits	# CBM Dishcarge Outfalls	Year 2000 CBM Discharges[1] (cfs)	Average Discharge per Outfall (cfs)
Upper Tongue River	18	122	1.77	0.0096
Upper Powder River	129	790	7.61	0.0096
Clear Creek	13	48	0.008	0.0002
Middle Powder River	28	139	1.35	0.0097
Little Powder River	97	533	11.9	0.022
Antelope Creek	49	171	0.32	0.002
Upper Cheyenne River	32	175	8.63	0.049
Upper Belle Fourche River	240	1,766	35.7	0.020
Total	606	3,744	67.3	0.015

Source: WDEQ 2001

1 Calculated from Table 3–3.

Discharge Volumes/Flow

On average, point source discharges from existing CBM operations in the Project Area range from 0.0002 to 0.049 cfs, or about 1 to 25 gpm, at each discharge outfall. As stated previously, these flows are reduced by conveyance losses in the stream channels and minimal or no discharged water is reaching the main stems. Most of the discharges are occurring in the Upper Belle Fourche River, Upper Powder River, Middle Powder River, and Little Powder River sub-watersheds.



LEGEND

- 4th Level Watershed Boundary
- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary
- 6324970 USGS Gaging Station

CBM Outfall Density Per Section

- 1 - 4 CBM Outfall Locations
- 5 - 10 CBM Outfall Locations
- 11 - 30 CBM Outfall Locations

Water Production in Barrels Per Sub-Watershed

- High (Greater Than 48,491,981)
- Moderate (6,590,000 to 42,740,000)
- Low (Less Than 1,770,000)

N

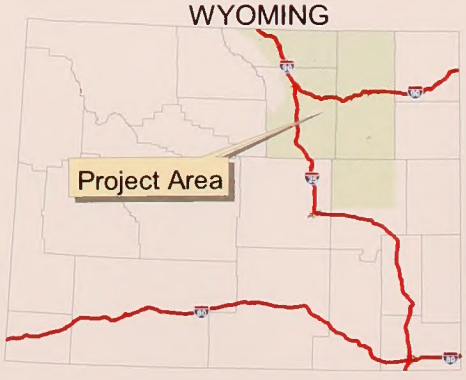
Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 3-3 OUTFALL DENSITY, WATER PRODUCTION AND USGS GAGING STATIONS	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_v1\data\maps.apr Layout--Outfalls
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

Surface Water Quality

The chemical composition of surface water changes continually. Most changes are related to the amount of water and the source of water flowing in a stream at a given time. Surface water quality is directly influenced by higher amounts of precipitation associated with the mountainous regions and the composition of rocks in the area. Streamflows resulting from snowmelt and precipitation are in contact with soils and rocks for only a limited time; thus, these waters have only small amounts of dissolved minerals. Surface water type also changes with elevation. Streams in the higher elevations are typically calcium bicarbonate type waters. As the streams flow across the lowlands, both as natural flow and irrigation return flow, they change to sodium sulfate type waters. The waters are typically alkaline and have moderate to high levels of hardness.

Ambient Water Quality

Surface water quality data for inorganic chemical constituents and trace metals from the Project Area are summarized in Appendix E. Selected surface water quality monitoring stations in the Project Area are illustrated on Figure 3–3. Water quality in various stream segments within the Project Area is affected by irrigation return flows, runoff from erosive soils, and other natural background conditions. General surface water quality conditions in the Project Area are discussed below.

Metals

Concentrations of trace metals in surface waters draining the Project Area are generally low. Levels of iron and manganese that exceed the secondary drinking water standards of 0.3 mg/L and 0.05 mg/L, respectively, have been detected in surface water in the Project Area occasionally. Manganese and iron can cause staining and bitter tastes, but are not present in concentrations that would limit use of the water for stock watering or irrigation. Of samples collected at the water quality monitoring stations identified in Appendix E, average manganese concentrations ranged from less than detectable to 2.1 mg/L. Average iron concentrations ranged from less than detectable to 0.2 mg/L.

Concentrations of selenium greater than the drinking water standard of 10 micrograms per liter (µg/L) have been measured in surface water from localized streams in the Project Area (Lowry et al. 1986). Most of the high selenium values have been detected in the South Fork of the Powder River near Kaycee. Over the period 1949 to 1994, the average selenium value at this location was 17 µg/L (USGS 2001c). Selenium sources within this sub-watershed are geologic in their origin (Seiler et al. 1999). Although selenium concentrations exceed the drinking water standard, the stream is not used as a public water supply (USEPA 2001). Selenium concentrations do not limit the use of the water for stock watering, however, due to uptake of selenium, certain vegetation could become toxic to livestock. Selenium concentrations greater than 2 to 5 µg/L can cause reproductive failure in fish and wildlife (U.S. Department of the Interior 1987).

Dissolved Solids

TDS represents the sum of all dissolved constituents in a water sample, and therefore, is often used as an overall indicator of water quality. Concentrations of

TDS typically are lower in streams at high elevation and increase significantly as streams flow away from the mountains.

In most of the Project Area, concentrations of TDS typically exceed the secondary drinking water standard of 500 mg/L. Nearly 50 percent of the TDS concentrations measured at water quality monitoring stations in the Project Area are greater than 2,000 mg/L (Lowry et al. 1986). In the southwest portion of the Project Area, average TDS concentrations range from 566 mg/L in the North Fork of the Powder River to 2,660 mg/L in the South Fork of the Powder River. In the central portion of the Project Area, stations in the Middle Powder River and Upper Powder River sub-watersheds report average TDS concentrations of 1,389 and 1,888 mg/L, respectively. On the eastern side of the Project Area, TDS measurements in the Dry Fork of the Cheyenne River average 1,375 mg/L, and are slightly higher in the Upper Cheyenne River, with an average TDS concentration of 2,109 mg/L. The Upper Belle Fourche River in the northern portion of the Project Area averages 1,718 mg/L TDS.

Suspended Sediment

Concentrations of suspended sediment are high throughout the Project Area. Concentrations reflect the highly erosive nature of the shale deposits through which the rivers flow. Sediment concentrations increase in a direct relationship to flow. In the Project Area, suspended sediment concentrations averaging 695 mg/L are reported in the Upper Belle Fourche River. Concentrations are significantly higher in the Upper Powder River, where average suspended sediment concentrations range from 14, 400 mg/L to 19,095 mg/L.

Sodium Adsorption Ratio

Sodium adsorption ratio (SAR) represents the proportion of sodium ions to calcium and magnesium ions in water. SAR is an indicator of the potential for water to impact soil structure. Surface waters having SAR values of 10 to 15 and greater used for irrigation pose a potential hazard to the health of individual plants growing in the irrigated soils, and thus, to the productivity/yield of the irrigated cropland. The application of irrigation waters with high SAR values results in a disproportionate concentration of sodium adsorbed by the soil at the expense of calcium and magnesium, which alters the physical condition of the soil growth medium. The sodium imbalance causes soil structure to breakdown and the soil particles to disperse. This is particularly true with clayey soils.

Average SAR values in the Project Area have ranged from <1 to 31.7. The highest SAR value was reported in Salt Creek, near Sussex. In the Upper Powder River, average SAR values have ranged from 4.8 to 6.3. Measurements in the Upper Belle Fourche River and the Little Powder River are similar, ranging from 5.1 to 6.1, and 5.9 to 6.1, respectively. Average SAR values in Clear Creek range from 1.1 to 1.4.

Temperature

The temperature of water in streams within the Project Area can range from 0 degrees Celsius (C) during winter to 25°C or more during late summer (Lowry et al. 1986). Water temperatures in streams also vary as a function of elevation. Historically, water temperature measurements in the Project Area have ranged from

4.2 to 17.0°C (USGS 2001c). For the period of record from 1946 to 2000, mean water temperatures ranged from 9.6 to 11.6°C in the Upper Powder River at Arvada. For the period of record from 1972 to 2000, mean values ranged from 8.7 to 10.8°C in the Upper Belle Fourche River below Moorcroft. The highest mean water temperature (17°C) in the Project Area was measured in the South Fork of the Powder River near Kaycee (USGS 2001c).

Impaired Water Bodies

The quality of water in the rivers and streams within the Project Area is protected for designated uses in accordance with the State of Wyoming's water quality standards. The State of Wyoming's 305(b) Report for 2000 lists waterbodies with water quality impairments in the Tongue River, Upper Powder River, Upper Belle Fourche River, and the Middle North Platte River sub-watersheds (WDEQ 2000). Listed impairments are caused primarily by pathogens; trace metals, specifically selenium and arsenic; chloride; TDS; and salinity. Most sources of the impairments are unknown.

A segment of the Powder River below Salt Creek is impaired as a Class 2 warm water fishery (2WW) by selenium and chloride. Certain waterbodies in the North Platte River basin are impaired for use by wildlife and for agriculture. The Kendrick Reclamation Project removes water from Seminoe and Alcova Reservoirs for irrigation use northwest of Casper. However, much of the irrigated soil contains naturally high levels of selenium, which is readily dissolved and transported by the irrigation water. Studies performed by the USGS have determined that irrigation return flows contain high levels of selenium, which result in selenium loading into the North Platte River and several streams, wetlands, and reservoirs near the reclamation project (Sieler et al. 1999).

Waterbodies delisted from the State of Wyoming's 1998 303(d) list include a segment of the Upper Belle Fourche River below the Hulett Wastewater Treatment Plant (WWTP), and a segment of the Tongue River below the Forest Service WWTP. These delistings resulted from the establishment of Total Maximum Daily Load's (TMDLs) for ammonia, residual chlorine, and fecal coliform (WDEQ 2000).

Surface Water Distribution

The distribution of surface water flows in the Project Area is influenced by natural streamflow, CBM produced water discharges, and releases from reservoirs.

Streamflows

About 80 percent of the streams in the Project Area are ephemeral and interrupted streams. Major perennial streams in the Project Area include the Upper Tongue River, Upper Powder River, Middle Powder River, Little Powder River, Clear Creek, and Crazy Woman Creek.

CBM Produced Water

The distribution of existing surface water flows are influenced by CBM produced water discharges, depending on the volume of water produced and how the water is handled. Sub-watersheds with high volumes of CBM water production, such as

the Upper Belle Fourche River, Little Powder River, and Upper Powder River sub-watersheds, exhibit more continuity in flows than sub-watersheds with limited CBM development. Water handling also influences the distribution of surface flows. Direct discharges of CBM produced water into surface drainages have a greater influence on surface flows than surface discharge into flow-through stock reservoirs or infiltration impoundments.

Reservoir Outflows

Reservoirs in the Project Area are used to hold water supplied from snowmelt, and to make stored water available during summer and fall, periods of limited precipitation and heavy demand. Major reservoirs receiving potential CBM produced water discharges in or downstream of the Project Area include Keyhole Reservoir in the Upper Belle Fourche River sub-watershed, Lake DeSmet, an off-channel reservoir, in the Clear Creek sub-watershed, and Angostura Reservoir in the Upper Cheyenne River sub-watershed. The storage capacities of these three reservoirs are 340,000 acre-feet, 239,000 acre-feet, and 103,431 acre-feet, respectively. Annual releases to the Belle Fourche River from Keyhole Reservoir average about 16,000 acre-feet. Numerous small reservoirs and stock reservoirs also exist in the Project Area.

Surface Water Use

Surface water withdrawals in the Project Area totaled 1,636 million gallons per day (mgd) in 1995. Table 3–8 summarizes water use within the PRB in 1995 (USGS 1995). Nearly 35 percent of the surface water withdrawals were from the Upper Tongue River sub-watershed. Surface water consumption in the Project Area is predominantly associated with irrigation use. About 98 percent of the surface water withdrawals (1,602 mgd) are used for irrigation. Nearly 72 percent of the irrigation occurs in the Upper Tongue River, North Fork of the Powder River, Upper Powder River, and Clear Creek sub-watersheds. Mining use accounts for only one percent, or 18.26 mgd of the total surface water withdrawals. About 47,130 people living in the Project Area obtained their water supply from surface water sources in 1995, consuming 11.75 mgd, or about one percent of the surface water withdrawals (USGS 1995).

Permitted Water Diversions/Structures

Surface water adjudication rights in the Project Area are summarized in Table 3–9. Of the 78,316 filings of surface water adjudications, 57 percent are used for irrigation. About 20 percent are used for domestic purposes. The remaining 23 percent of the surface water adjudications in the PRB are used for stock watering and other purposes. The adjudication does not necessarily mean that all of the water is available every year for the intended use, but reflects legal claims on the water. Permitted reservoirs and stock reservoirs in the Project Area are summarized in Table 3–10.

Municipal Water Sources

Communities in the Project Area utilizing surface water as a municipal water supply include the City of Sheridan, and the towns of Buffalo, Dayton, and Ranchester (USEPA 2001). Surface water sources in the Tongue River sub-

watershed supply the communities of Sheridan, Dayton and Ranchester. Buffalo utilizes surface water from the Clear Creek sub-watershed. Surface water withdrawals for municipal water supplies account for about one percent of the total surface water use in the Project Area. The majority of municipal water supplies in the Project Area are acquired mainly from groundwater sources.

Table 3–8 1995 Surface Water Use within the Powder River Basin

	Water Use by Category (mgd)						
Sub-watershed	Public Supply	Commercial	Domestic	Industrial	Mining	Livestock	Irrigation
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.11	90.66
Upper Tongue River	5.37	0.02	0.00	0.01	0.03	0.7	526.72
Middle Fork Powder River	0.00	0.01	0.00	0.00	0.21	0.13	70.54
North Fork Powder River	0.00	0.00	0.00	0.00	0.28	0.33	276.27
Upper Powder River	0.00	0.00	0.00	0.00	0.52	0.27	134.4
South Fork Powder River	0.00	0.00	0.00	0.00	0.71	0.19	43.98
Salt Creek	0.39	0.01	0.00	0.00	0.38	0.11	28.21
Crazy Woman Creek	0.00	0.00	0.00	0.00	0.09	0.09	63.04
Clear Creek	1.26	0.02	0.04	0.00	0.08	0.29	215.44
Middle Powder River	0.00	0.00	0.00	0.00	0.12	0.04	14.4
Little Powder River	0.00	0.00	0.00	0.00	2.65	0.1	0.39
Little Missouri River	0.00	0.00	0.00	0.00	0.37	0.15	8.56
Antelope Creek	0.00	0.00	0.00	0.00	1.78	0.11	6.79
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.15	0.06	5.05
Upper Cheyenne River	0.00	0.00	0.00	0.00	4.31	0.14	2.92
Lightning Creek	0.00	0.00	0.00	0.00	0.2	0.1	6.86
Upper Belle Fouche River	0.00	0.03	0.03	0.02	4.37	0.39	17.3
Middle North Platte River	4.73	0.07	0.02	0.02	1.98	0.53	90.32
Project Area Total	11.75	0.16	0.09	0.05	18.26	3.93	1,601.85

Source: USGS 1995

Table 3–9 Surface Water Adjudications within the Powder River Basin

	Use			
Sub-Watershed	Irrigation	Domestic	Stock	Other
Little Bighorn River	1,120	42	67	39
Upper Tongue River	19,885	8,824	1,728	1,067
Middle Fork Powder River	2,024	423	450	44
North Fork Powder	7	6	24	0
Upper Powder River	2,085	668	1,810	36
South Fork Powder River	196	42	195	21
Salt Creek	4	33	57	6
Crazy Woman Creek	3,508	787	648	501
Clear Creek	10,458	2,032	989	4,091
Middle Powder River	454	47	324	6
Little Powder River	2,299	776	1,534	148
Little Missouri River	85	0	116	0
Antelope Creek	884	158	728	273
Dry Fork Cheyenne River	253	67	384	36
Upper Cheyenne River	53	72	366	151
Lightning Creek	410	7	356	50
Upper Belle Fouche River	954	1,792	1,016	246
Middle North Platte River	136	88	113	17
Project Area Total	44,815	15,864	10,905	6,732

Source: WSEO 2001

Table 3–10 Surface Water Impoundments in the Powder River Basin

Sub-Watershed	# Permitted Reservoirs	Average Capacity (acre-feet)	# Permitted Stock Reservoirs[1]	Average Capacity (acre-feet)
Little Bighorn River	26	55.0	10	9.2
Upper Tongue River	287	32.8	321	4.2
Middle Fork Powder River	30	56.7	68	4.0
North Fork Powder	0		0	
Upper Powder River	162	46.0	345	6.0
South Fork Powder River	13	59.9	20	8.9
Salt Creek	6	44.9	16	3.5
Crazy Woman Creek	116	95.7	86	5.8
Clear Creek	123	36.0	187	5.1
Middle Powder River	17	19.6	63	6.0
Little Powder River	117	50.5	346	4.5
Little Missouri River	11	29.2	24	4.4
Antelope Creek	58	79.3	101	4.6
Dry Fork Cheyenne River	27	60.4	85	5.2
Upper Cheyenne River	19	30.6	49	4.3
Lightning Creek	28	92.6	75	5.6
Upper Belle Fouche River	103	49.2	167	5.3
Middle North Platte River	18	110.0	13	8.1
Project Area Total	1,161	55.8 (Avg)	1,976	5.6 (Avg)

Note:
1. As per WSEO regulations, stock reservoirs limited to 20 acre-feet.
Source: WSEO 2001.

CBM Produced Water Use/Treatment

The primary method currently used for handling the produced water is direct surface discharge through discharge outfalls. Outfalls may feed into small stock reservoirs, constructed infiltration basins, or other facilities before the outflows reach surface drainages. In addition to direct surface discharge, alternate methods of disposing of produced water being utilized, tested, or considered by CBM operators include evaporation enhancement, re-injection, percolation, irrigation, surface containment, and treatment (Western Gas Resources, Inc. 2001). The method of handling the produced water varies with water quality, water volumes, and desires of the surface owners. A discussion of each of these options is included below.

Surface discharge of the produced water represents both direct discharge and discharge retained temporarily in flow-through upland or bottom-land impoundments. These discharges are permitted by the WDEQ after the issuance of an NPDES permit.

Evaporation enhancement utilizes atomizers installed on towers above the ground or on floating platforms in the middle of a reservoir. Atomizers placed aboveground have been successful in managing the volumes of CBM water produced, but due to their limited use, it is unknown what the duration of use would be to avoid build-up of trace elements in the ground beneath the tower. Pilot testing utilizing atomizers placed on floating platforms in the middle of a reservoir has indicated that 50 percent of the CBM water can be eliminated. Build-up of trace elements in the reservoir is purged during heavy runoff periods when the reservoir overflows. This method of water handling is being utilized at multiple loca-

tions within the Project Area. Large surface area ponds have been built to enhance evaporation, although this method is less favorable due to the high cost and surface impact.

Re-injection is accomplished by injecting the water into deep disposal wells. Potential injection zones include the sands and coals within the Wasatch and Fort Union Formations. Data are limited regarding the success of this method of water handling. A nine-well injection project was initiated into the Wall Coal, using produced water from the Anderson/Canyon Coal. These wells did receive water for six months; however, injection pressures became so elevated that fracturing became a concern.

A ten-well injection project was initiated into the Fort Union Formation near the City of Gillette. Results of injection were favorable. Since the receiving aquifer had been partially depleted by a multitude of shallow private and municipal water wells, injection could occur at low surface pressures. One operator indicated that this would not be a feasible alternative for water handling in areas where the aquifer is not partially depleted, due to excessive injection pressures.

Percolation of the produced water into scoria formations or other near shallow aquifers is being tested by at least one company. This method of water handling utilizes a trench or narrow pit excavated along a scoria bed, and allows the produced water to percolate from the trench or pit into the scoria bed. Thus far, this method is only being utilized in areas where the scoria bed does not outcrop, due to the potential for seepage.

Infiltration basins are constructed to dispose of the produced water through infiltration into the underlying alluvial or basin fill deposits, clinker, or sandy bedrock horizons. These basins are situated in existing drainages and in upland areas. Infiltration of the produced water can be 30 percent or more. The basins are designed not to discharge infiltrated water back to the surface.

CBM produced water is often suitable for irrigation use. Suitability for irrigation depends upon interaction with soil types, SAR values, salinity values, and types of crops grown. Methods of irrigation include flood irrigation using spreader dikes, and center pivot systems.

Surface containment includes upland impoundments, both lined and unlined, with no direct surface discharge or lateral subsurface movement of water and down-gradient expression in seeps or springs. It is estimated that as much as 95 percent of the produced water in certain areas of the Project Area is being contained in reservoirs. Some operators are working closely with the landowners, U.S. Department of Interior, Fish and Wildlife Service (USFWS), Wyoming Game and Fish Department (WGFD), and other agencies to establish the reservoirs as bird rehabilitation areas. The reservoirs are being constructed incorporating islands providing protective habitat for birds as well as game fish.

Treatment of the produced water is utilized to amend the water quality to meet NPDES standards prior to surface discharge, using a chemical process, a reverse-osmosis process, or a combination of both. Pilot testing using this method of water handling has been performed with varying degrees of success.

Physiography, Geology, Paleontology, and Mineral Resources

Physiography

Physiography

The PRB is part of the Missouri Plateau of the Great Plains (Trimble 1980). This region is characterized by rolling uplands that have been greatly dissected by tributaries of the Missouri River system. The great continental glaciers never extended into the PRB. The Bighorn Mountains, which are part of the Rocky Mountains, lie just west of the PRB, partially within the westernmost portion of the Project Area. The east slope of this imposing mountain barrier, facing the PRB, is steep and rugged for the most part, and is cut by many deep, narrow canyons (Keefer 1974).

The PRB is a structural basin extending about 220 miles from north to south, and generally less than 95 miles from east to west, that formed at the foot of the Bighorn Mountains. The PRB is bounded on its margins by upturned rocks or mountainous masses rising from the plains. On the east, the PRB is bounded by the Black Hills. On the south, the PRB is bounded by the Casper arch, the Laramie Mountains, and the Hartville Uplift (Macke 1993). To the north and northeast, the terrain of the PRB merges with, and cannot be distinguished from, the remainder of the Missouri Plateau (Keefer 1974).

The PRB consists of a dissected, rolling upland plain, with low to moderate relief, broken by buttes, mesas, hills, and ridges. Extensive areas of open high hills in the northern portion of the Project Area indicate rough, broken terrain where moderate to deep erosion has occurred (Keefer 1974). Erosion-resistant clinker, produced by the natural burning of coal beds in the PRB, caps many hills and ridges within the Project Area with a characteristic broken, red brick or scoria-like rock. Elevations in the Project Area range from 3,350 to 9,250 feet above msl.

The present-day landforms of the semiarid PRB have been shaped mostly by the action of water, even though precipitation is low and evaporation greatly exceeds precipitation. The drainages dissecting the Project Area are incised, typically are ephemeral or intermittent, and do not naturally provide permanent or year-round water sources. Major river valleys have wide, flat floors and broad floodplains. Badlands, such as the Powder River Breaks and Tongue River Breaks, have formed where water has flowed over sloping surfaces of soft, fine-grained materials. Playa lakebeds are relics from wetter periods. Surface springs and seeps are fed by groundwater from shallow aquifers. Drainage catchments and open basins are separated by upland landforms such as hills, ridges, and buttes.

The PRB is drained toward the north and east by the Tongue, Powder, Little Powder, Belle Fourche, and Cheyenne Rivers, which all flow into the Missouri River system. The Project Area forms a low divide among these smaller drainage systems. Northwestern and western portions of the area, generally those areas west of Highway 50 and north of Highway 387, are drained by the north-flowing Powder River, which is tributary to the Yellowstone River of the Missouri River system. A small area within the northwestern portion of the Project Area is

drained by the Tongue River, another tributary of the Yellowstone River. The northeastern portion of the Project Area is drained by tributaries of the Little Powder River, which flows into the Powder River. The area east of Highway 50, located between the communities of Gillette and Wright, is drained by the Belle Fourche River and its tributaries. The areas south and east of Highway 387 are drained by the Cheyenne River.

Geology

The PRB is a northwest-southeast trending structural basin filled with Cenozoic sediments of continental origin that were derived from surrounding uplifted areas (Brown 1993). The PRB formed during the Laramide Orogeny (mountain building era) about 60 million years ago (Glass and Blackstone 1996).

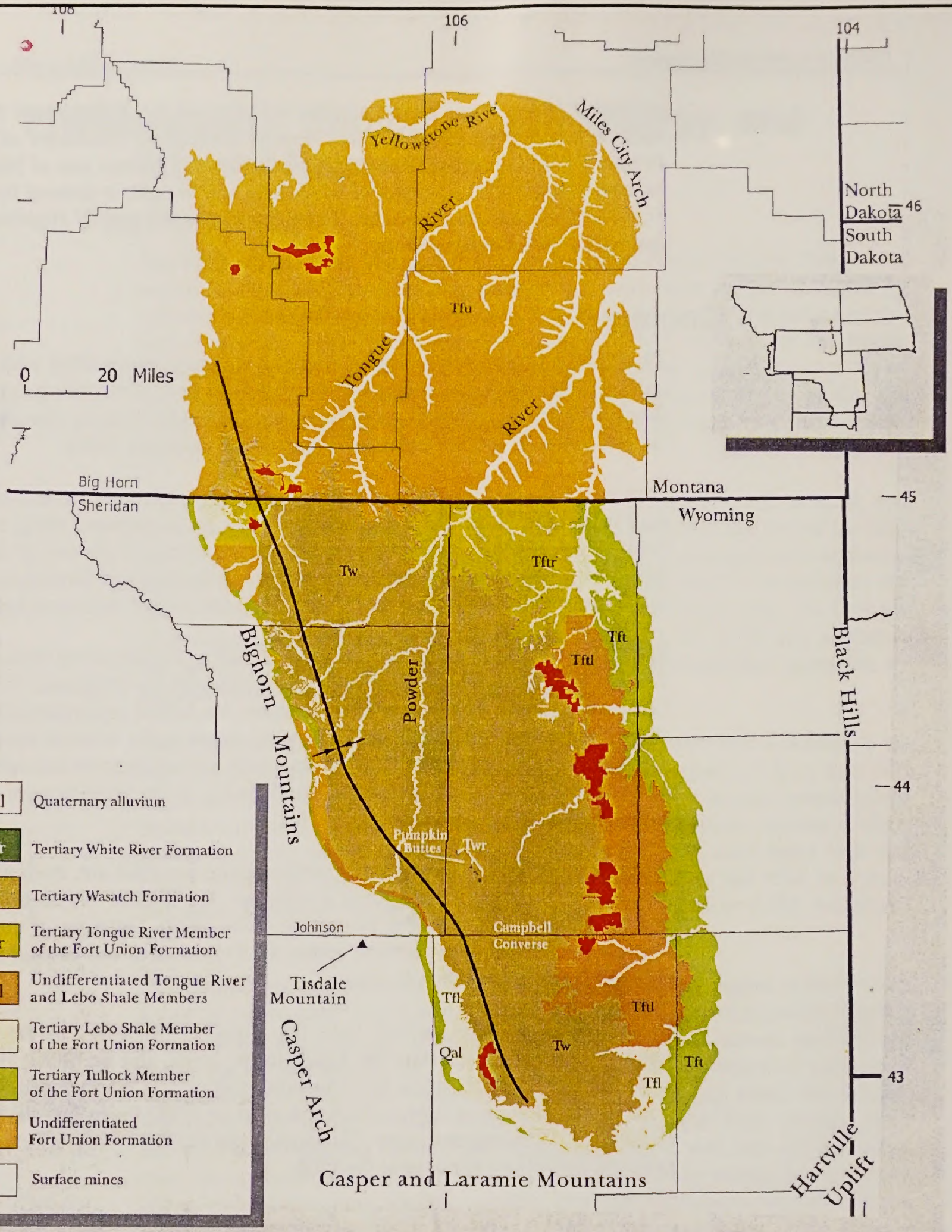
Portions of the eastern flank of the Bighorn Mountains also are included within the Project Area. The Paleozoic and Mesozoic rocks exposed along the eastern flank of the Bighorn Mountains, within the westernmost portion of the Project Area, are stratigraphically below and older than the geologic formations that may be affected by CBM development in the PRB, and are not described further.

The PRB was shaped by folding and minor faulting that occurred during the early Tertiary period, and ended before the deposition of the Oligocene White River Formation (Macke 1993). The PRB margins are folded asymmetrically upward along a northwest trending basin axis that is closer to the western margin than it is to the eastern margin. Rock layers dip gently several degrees throughout much of the PRB, however, dips steepen significantly in the western portions of the basin (Macke 1993).

Geologic formations exposed at the surface within the PRB are, from youngest to oldest, the Oligocene White River Formation, the Eocene Wasatch Formation, and the Paleocene Fort Union Formation (Ellis 1989). Outcrops of the geologic formations exposed at the surface within the Project Area can contain significant amphibian and mammalian fossils.

Basin sediments were derived from the Bighorn Mountains to the west, the Laramie Mountains and Hartville Uplift to the south, and the Black Hills to the east. The early Tertiary basin fill sediments of the PRB (Wasatch and Fort Union Formations) attain a maximum thickness of over 6,500 feet along the basin axis (Brown 1993). Along drainages, Quaternary alluvial deposits overlie the Tertiary geologic formations exposed in the PRB.

The Cretaceous Lance Formation, of continental origin, underlies the early Tertiary formations in the PRB (Brown 1993) and is exposed only in the southern and western portions of the Project Area, outside the area where Tertiary coals occur (Ellis 1989). The Lance Formation is stratigraphically below and older than the geologic formations that may be affected by CBM development in the PRB and is not described further. The generalized geology of the PRB is shown in Figure 3–4. Geologic formations occurring in the PRB are shown in Figure 3–5.



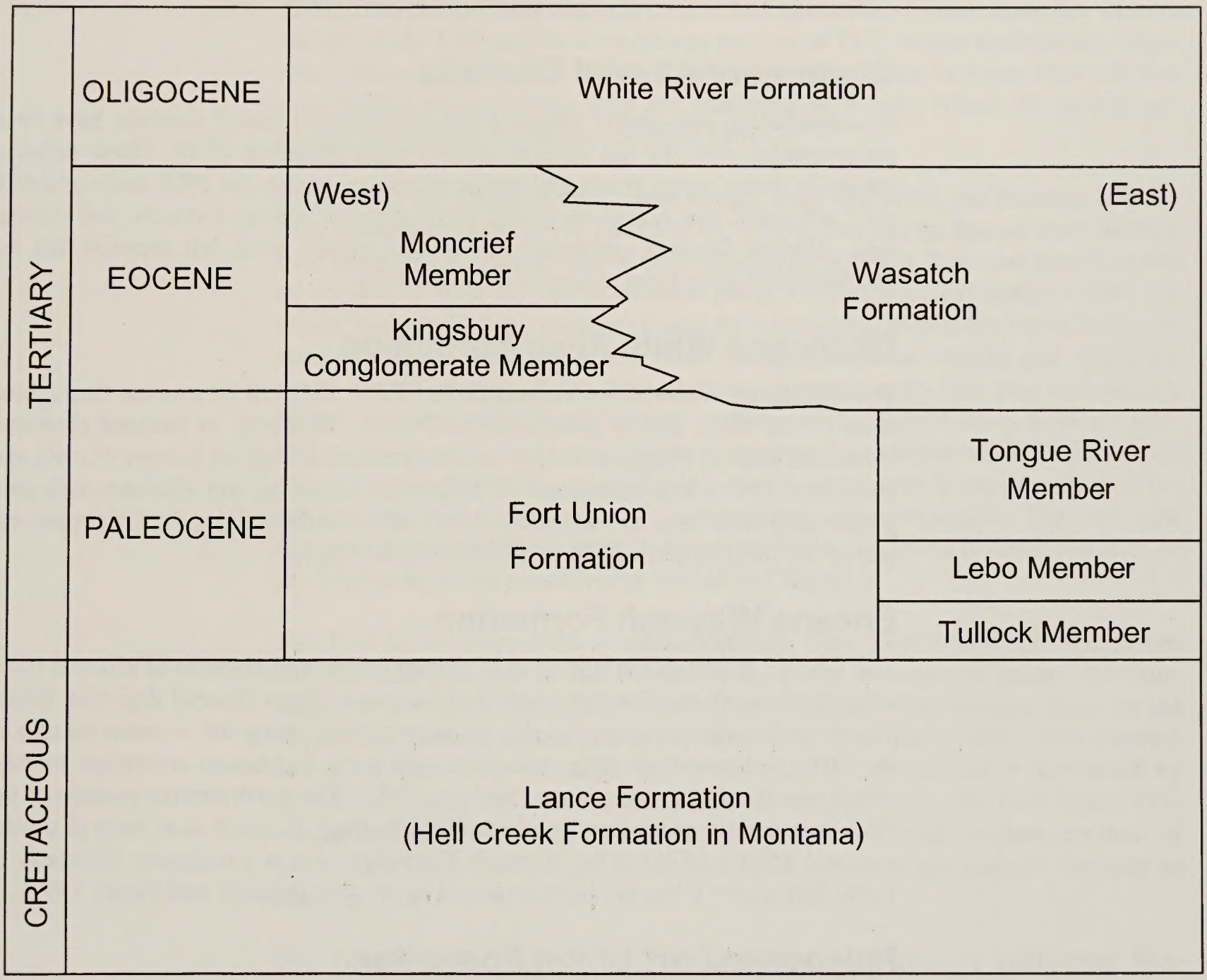
NORTH

Source: Flores et al. 2001

POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 3-4
GENERALIZED GEOLOGY OF THE POWDER RIVER BASIN

ANALYSIS AREA: POWDER RIVER BASIN	
Date: 12.11.01	Drawing File: 1011 SCHEMATICS.DWG
Scale: NTS	Drawn By: ETC



POWDER RIVER BASIN OIL/GAS EIS PROJECT	
FIGURE 3-5 STRATIGRAPHIC NOMENCLATURE FOR THE POWDER RIVER BASIN	
ANALYSIS AREA: POWDER RIVER BASIN	
Date: 12.11.01	Drawing File: 1011 SCHEMATICS.DWG
Scale: NTS	Drawn By: ETC

Source: Seeland 1992

The natural burning of coal beds in the PRB over the past few million years has consumed billions of tons of coal and has baked and melted the overlying bedrock (see page 3–44). This rock, known as clinker, presently covers about 460 square miles of the Project Area (Heffern and Coates 1997). Clinker rock types vary greatly, depending on lithology of the parent rock, temperature and duration of heating, and degree of oxidation (Coates and Heffern 1999).

Quaternary Alluvial Deposits

Unconsolidated and poorly consolidated Quaternary alluvial deposits have been accumulating over the last several million years (Trimble 1980). These deposits generally occur along rivers and major drainages within the PRB and consist of clay, silt, sand, and gravel occurring as floodplains, stream terraces, and alluvial fans. Alluvial deposits commonly are 30 feet or less thick, but deposits that are 100 feet thick have been measured (Wells 1982).

Oligocene White River Formation

The Oligocene White River Formation has been removed by erosion throughout most of the PRB, and is present in the Project Area only as isolated erosional remnants, such as Pumpkin Buttes in southwestern Campbell County (Lewis and Hotchkiss 1981). It is composed of tuffaceous claystone and siltstone with conglomerate lenses near its base (Love et al. 1987). It dates from the Oligocene epoch of the Tertiary period (24 to 37 million years ago).

Eocene Wasatch Formation

The Eocene Wasatch Formation is of stream origin and consists of alluvial mudstone from overbank flood deposits and sandstone from channel deposits. Minor constituents include coarse conglomerate occurring along the western margin of the PRB, carbonaceous shale, and thick coal beds. Sandstone comprises an estimated one-third of the sequence (Seeland 1992). The northwestern portion of the PRB is underlain at shallow depths by locally thick Wasatch coal beds (Culbertson and Mapel 1976). The Wasatch Formation has a maximum thickness of 1,400 feet where it has not been removed by erosion (Molnia and Pierce 1992).

Paleocene Fort Union Formation

The Paleocene Fort Union Formation, of continental origin, consists of sandstone, siltstone, claystone, and beds containing lignite and sub-bituminous coal formed in stream, lake and swamp environments. Fort Union sediments were deposited by north-flowing braided, meandering streams, and swamps in the basin center, and by alluvial fans at the basin margin (Flores et al. 1999). Numerous thick and laterally widespread coal beds occur within the Fort Union Formation (Lewis and Hotchkiss 1981). Goolsby and Finley (2000) suggest the Fort Union coals were continuously deposited in a migrating depositional center. Flores and Bader (1999) report the thickness of the Fort Union Formation to be as much as 5,200 feet along the basin axis of the western PRB in Wyoming.

The thickness of the Fort Union (Wyodak-Anderson) coal zone varies greatly within the PRB. The Wyodak-Anderson coal zone has a maximum net coal thickness of 284 feet, using coal beds greater than 2.5 feet thick, and the entire

zone is more than 600 feet thick in the center of the basin (Ellis 1999). The total thickness of the coal beds in this zone commonly range from 50 to150 feet (Seeland 1992). The coal beds average 25 feet in thickness and contain clastic (non-coal) interbeds ranging from a few feet to 150 feet in thickness (Ellis 1999). The coal beds merge in places into a single bed as much as 200 feet thick (Seeland 1992). The thickness of a single coal seam is less than 20 feet along the western margin of the PRB and in the northern portion of PRB within southeastern Montana (Seeland 1992). The thickness of a single coal seam is more than 100 feet near Wright and extending west and northwest of Wright, within the central portion of the PRB in Wyoming (Seeland 1992).

Regionally, the different coal zones merge, split, and pinch out laterally in complex patterns (Flores 1999, Flores et al. 1999), and can be traced intermittently over distances of several tens of miles (Pierce et al 1990). The coal zone contains up to six coal beds in a given location (Ellis 1999). Flores and Bader (1999) and others have studied the number of coal beds occurring within the Fort Union coal zone in different portions of the PRB. Along the eastern margin and within the south central portion of the Project Area, predominantly one coal bed occurs. Within the north-central and western portions of the Project Area, there are typically three or more coal beds. Within the remaining portions of the Project Area, there are predominantly two coal beds. Important coal beds are described in the coal section of this chapter, under mineral and energy resources. The coal zone nomenclature used in this analysis for groundwater modeling is described later, at the beginning of the groundwater section in Chapter 4.

The Fort Union Formation is subdivided into three members within the central and northern portions of the Project Area. From youngest to oldest, the three members are the Tongue River, Lebo, and Tullock. The Tongue River is the uppermost member and is rich in sandstone and coal. The middle Lebo member has a high percentage of shale, and the lowest Tullock member is dominated by sandstone. Along the western margin of the Project Area, the Fort Union Formation is undifferentiated. East of Gillette and within most southern portions of the Project Area, the Tongue River and Lebo members are mapped together as one unit (Ellis 1989).

The Tongue River member is of composed of thick channel sandstones, fine-grained overbank deposits, and coal beds. This unit thins toward the southeastern portion of the PRB (Pierce et al. 1990). The Tongue River member was formed during episodes of high-energy stream activity having intervening periods of quiet activity that led to the accumulation of thick peat deposits in swamps (Pierce et al. 1990). The maximum thickness of the Tongue River member is over 2,100 feet near the basin axis in the central portion of the Project Area. The Tongue River member thins toward the east, and is only 1,000 feet thick north of Gillette (Molnia and Pierce 1992). Flores and Bader (1999) report the thickness of the Tongue River member to be as much as 1,800 feet.

The Lebo member is of stream and lake origin and consists primarily of fine-grained deposits and some channel sandstones (Pierce et al 1990). It is characterized by dark shales containing discontinuous zones of white calcareous banding (paleosol horizons). In the northern PRB the Lebo contains rare beds of gray sandstone as much as 10 feet thick. In the southern PRB some coal beds, a few

thicker than two feet, occur within the Lebo and form clinker horizons. The Lebo member ranges in thickness from about 500 feet in the northwestern portions of the PRB to about 1,700 feet in the southwestern portions of the PRB (Brown 1993). The Lebo member thins toward the southeastern portion of the Project Area (Pierce et al 1990). Flores and Bader (1999) report the thickness of the Lebo member to be as much as 2,600 feet.

The Tullock member contains alluvial sediments deposited in a stream environment. It consists of fine-grained sandstone, sandy siltstone, shale, rare thin limestone, and coal. An estimated one-third of the sequence is comprised of channel sandstones. An estimated two-thirds of the sequence is comprised of fine-grained overbank deposits containing thin coal beds. Tullock sediments have a maximum thickness of about 370 feet in the north and 1,440 feet in the south (Brown 1993). Tullock sediments are thickest in the southeastern and western portions of the PRB. Flores and Bader (1999) report the thickness of the Tullock member to be as much as 740 feet.

Paleontologic Resources

Scientifically significant paleontologic resources, including vertebrate, invertebrate, plant, and trace fossils, are known to occur in many of the geologic formations within the Project Area. These fossils are documented in the scientific literature, in museum records, and are known by paleontologists and land managers familiar with the area.

The paleontologic potential of the Project Area was evaluated using the Probable Fossil Yield Classification (PFYC) developed by the FS, which is also employed by the BLM. The classifications include:

- Class 1: Igneous and metamorphic geologic units (excluding tuffs) that are not likely to contain recognizable fossil remains.
- Class 2: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.
- Class 3: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence.
- Class 4: Class 4 geologic units are Class 5 units that have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation. Proposed ground-disturbing activities would require assessment to determine whether significant paleontologic resources occur in the area of a proposed action and whether the action would impact the resources.
- Class 5: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils and/or scientifically significant nonvertebrate fossils and that are at high risk of natural degradation and/or human-caused adverse impacts.

The Project Area contains 34 mapped geologic units (Flores 2001, Love 1985, Love et al. 1987). Of these, one is classified as Class 1, two are classified as Class 2, 27 are classified as Class 3, none are classified as Class 4, and four are

classified as Class 5. The four units classified as Class 5 are the Morrison Formation, Lance Formation, Wasatch Formation, and White River Formation.

Most of the geologic units within the Project Area are located around the margins of the PRB and are relatively limited in their distribution. The most widely distributed units are the Wasatch Formation and Fort Union Formation, both of which are discussed below. Within the Project Area, the highly fossiliferous White River Formation (Class 5) occurs only on Pumpkin Buttes in southwestern Campbell County.

The Wasatch Formation (Class 5) is by far the most geographically widespread formation in the Project Area and is the bedrock geologic formation in most of the PRB in Wyoming (Murphey et al. 2001). Because they are mostly vegetated, the formations within the PRB have historically not been perceived to be as rich in fossils as nearby basins, such as the Bighorn and Wind River, which have extensive badland exposures. Nevertheless, the ubiquitous anthills in the PRB contain locally abundant remains of small animals (mouse to rabbit sized), which can be successfully sampled even in vegetated areas.

Murphey et al. (2001) determined no institution has collected articulated bones from the lower Eocene part of the Wasatch Formation in the PRB. The Eocene fossils consist primarily of isolated teeth, with more complete dentary/maxillary fragments comprising approximately 10 percent of total the total number of specimens in the Univeristy of Colorado Museum's collections. Articulated material, particularly a partial skeleton of the aberrant reptile *Champsosaurus gigas*, is known from older deposits of the Wasatch Formation. Such finds are very rare and appear to be restricted to the Paleocene part of the formation. The Wasatch Formation fossil localities include 106 localities recorded at the University of Colorado Museum, 4 localities recorded at the University of Wyoming Museum of Geology, and 46 localities listed in Delson (1971), who was collecting for the American Museum of Natural History. These localities were originally documented by Wood (Delson 1971).

The Fort Union Formation (Class 3) is not as widely distributed as the Wasatch Formation, but does occur around the margins of the PRB. This formation contains locally abundant fossil vertebrates, invertebrates, and plants, and samples an important time interval during the early Tertiary evolution of mammals. No Fort Union Formation localities from within the Project Area were identified during the museum record search for this analysis, but they do occur nearby in Montana.

Other fossil localities within the Project Area occur in the Mesaverde, Mowry, White River, and Gros Ventre Formations. Fossil localities from outside the Project Area from formations that exist within the Project Area were also identified during this analysis. This locality data were; however, utilized in the class designations recommended for each formation.

It should be emphasized that the lack of localities from any of the geologic units in the Project Area does not mean that no scientifically significant fossils are present. Much of the area within and surrounding the PRB in Wyoming has not been adequately explored for paleontologic resources and new scientifically significant fossil occurrences are being discovered regularly.

Mineral and Energy Resources

The Project Area is one of the major mineral development areas in North America. Coal, oil, gas, and uranium have been the principal mineral and energy resources extracted from the PRB.

Coal

The PRB contains some of the largest accumulations of low sulfur subbituminous coal in the world. Thick coal deposits occur at or near the surface along the eastern boundary of the Project Area, along a north-south trend situated west of both Gillette and Wright, and in the northwestern portion of the Project Area. Coal occurs at depth, below the surface, throughout most of the remainder of the Project Area. Coal from the PRB in Wyoming is valued for its clean-burning properties.

Glass (1997) describes important coal seams of the Powder River Coal Field in Wyoming. These descriptions are summarized in the following paragraphs. Important coal seams within the Wasatch Formation, from oldest to youngest, include the School, Badger, Felix, and Lake De Smet coals. Important coal seams within the Fort Union Formation, from oldest to youngest, include the Canyon, Anderson, Wyodak, and Big George coals.

The School and Badger coals within the Wasatch Formation are developed in the Dave Johnston deposit in the southern part of the PRB. The Felix coal is a persistent coal bed in the northern and central portions of the Project Area, and varies between 5 and 20 feet thick, up to 50 feet thick in the central and southern portions of Campbell County. Felix coal exposures located east of the Powder River in southern Campbell County have been burned (Coates and Heffern 1999). The Felix coal is not currently mined.

The Lake De Smet coal is the thickest known coal seam in the contiguous U.S. Although limited in areal extent, in the northwestern portion of the Project Area the Lake De Smet coal attains a thickness of 250 feet. The Lake De Smet coal is not currently mined, and the uppermost portions of this coal bed are burned over much of its area of occurrence.

The Canyon coal of the Fort Union Formation is a persistent 10 to 65 feet thick coal bed over most of the Project Area. It is correlative with the Monarch coal in the Sheridan area. The Anderson coal is well developed throughout most of the Project Area, and coalesces with the Canyon coal in the Gillette area to form the thick Wyodak coal, which is 25 to 190 feet thick, and averages 100 feet thick. The Wyodak coal has the largest strippable reserve base of any coal bed in Wyoming. In 2000, twelve surface coal mines located in Campbell and Converse Counties produced 323 million tons of coal from the Wyodak coal zone. The mines are located near the eastern boundary of the Study Area, near the outcrop of the Wyodak coal (Figure 2–1 and Figure 3–4), where the overburden thickness is lowest. Extensive clinker deposits exist east of many of the coal mines, which resulted form the spontaneous burning of the Wyodak coal near its outcrop.

Westward from Gillette the Wyodak coal splits into an Upper Wyodak coal comprised of the Anderson and Canyon coals, and a lower, less persistent, Lower

Wyodak coal. North of Gillette the Wyodak coal splits into an Upper Wyodak coal (including the Anderson coal) and a Lower Wyodak coal (including the Canyon coal). Farther west in the vicinity of the Campbell and Johnson county line, the Upper Wyodak coal thickens and becomes the Big George coal. However, in areas southwest of Gillette, both the Wyodak and the Big George coals are present, with the Big George coal zone positioned stratigraphically above the Wyodak coal zone.

The Big George coal is not exposed at the surface. It is reportedly up to 200 feet thick and averages over 100 feet thick. It occurs in the subsurface of the west central portion of the PRB at depths between 1,000 and 2,000 feet, and is not currently mined.

Coal resources in the northwestern portion of the Project Area are summarized by the BLM (1999a). The prominent coal beds within the Tongue River member of the Fort Union Formation are, from oldest to youngest, the Carney, Monarch, Dietz 3, Dietz 2, Dietz 1, Anderson, Smith, and Roland coals. North of Sheridan, underground coal mines operated between 1894 and 1953. Surface mining began in 1944, and continued until 1996. Two active surface coal mines (Decker and Spring Creek) are located northwest of the Project Area in southern Montana.

Most of the coal in the Project Area is federally owned. These federal coal lands are within the Wyoming portion of the decertified Powder River Federal Coal Region (BLM 1999b).

Coal Bed Methane

About 25 trillion cubic feet (tcf) of CBM may be recoverable from coal beds in the PRB within Wyoming (WSGS 2001). For this estimate, data for coals greater than 20 feet thick, occurring deeper than 200 feet below the surface were used, and a recovery factor of 67 percent was assumed.

De Bruin et al. (2001) describe CBM resources occurring in the PRB. CBM is natural gas (methane) occurring in coal beds. In the PRB, CBM was formed as buried plant material was subjected to bacterial activity during coalification (conversion to coal). CBM in the Powder River Coal Field is composed almost entirely of methane (CH_4), with minor amounts of carbon dioxide (CO_2), about 1.5 to 2.0 percent.

A large percentage of the CBM generated during coalification escapes to the surface or migrates into nearby rocks, but a portion is trapped within the coal beds (De Bruin and Lyman 1999). Gas is trapped and stored in coal beds in one of four ways: 1) as free gas in tiny pores or cleats (fractures) within the coal; 2) as dissolved gas in water within the coal; 3) as adsorbed gas on coal surfaces; or 4) as absorbed gas within coal molecules (De Bruin et al. 2001).

While it has been known for many years that methane often vents from shallow water wells and coal exploration drill holes in the PRB, drilling for CBM began in 1986 (De Bruin and Lyman 1999). The first economic production of CBM from the PRB occurred in the Rawhide Butte field just north of Gillette, where production began in 1989 (De Bruin and Lyman 1999, Sawyer and Jeffries

1999). CBM development has been expanding rapidly since 1993 (Flores et al. 2001) and began accelerating in 1997 (De Bruin et al. 2001).

Historical CBM development in the PRB is summarized by Flores et al. (2001). During 1976 to 1996, 1,169 CBM wells were drilled. CBM drilling during 1997 to 1999 increased dramatically to 4,379 wells. During 2000 CBM development activity exploded and 3,831 wells were drilled. About 4,000 CBM wells were producing as of October 2000. From January 1994 through May 2001, CBM production increased at a nominal rate of 65 percent per year.

During 2000 a total of 150,544,625 Mcf of methane and 370,994,154 Bbls of water were produced from PRB coal beds in Wyoming (WOGCC 2001a). By the end of 2001, a total of about 12,077 CBM wells will have been drilled or permitted for drilling in the Project Area. As of November 30, 2000 an estimated 4,093 CBM wells were producing (BLM 2000).

At the time CBM development accelerated in the PRB, Western's MIGC pipeline was the only line out of the basin, and its capacity was filled rapidly (Shirley 2000). De Bruin et al. (2001) describe new gas pipelines in the Project Area. Three major pipelines (large diameter, high pressure gathering lines) were built in the PRB during 1999 and 2000: Bighorn Gas Gathering; Fort Union; and Thunder Creek. Currently CBM flows south out of the PRB on three interstate pipelines and to the north on one interstate pipeline (Sawyer and Jeffries 1999). As of early 2001, nearly 0.5 Bcf of gas per day was being transported out of the PRB (De Bruin et al. 2001).

Oil and Gas

Conventional (non-CBM) oil and gas exploration and production also have occurred for many years within the Wyoming portion of the PRB. Non-CBM oil and gas fields are concentrated within the central, eastern, and southern portions of the Project Area, and the infamous Salt Creek and Teapot Dome oil fields are located on the southwestern shoulder of the PRB (Lageson and Spearing 1991). Wyoming's annual oil production was increasing during the 1950s and 1960s, peaked at nearly 160 million barrels in the early 1970s, and has been declining since then (WOGCC 1998). According to WOGCC production statistics, 336 fields were producing non-CBM oil or gas within the Project Area during 2000 (WOGCC 2001a,c). Nearly 25 million barrels of oil and nearly 60 million Mcf of natural gas were produced from non-CBM PRB fields in Wyoming during 2000 (WOGCC 2001). PRB production comes from a variety of upper and lower Cretaceous strata, as well as from upper Paleozoic strata in the northeastern part of the basin (Lageson and Spearing 1991).

There are currently about 2,546 productive non-CBM wells within the Wyoming portion of the PRB. About 1,347 existing non-CBM wells are federal wells, 1,006 well are fee wells, and 193 wells are state wells (WOGCC 2001c). About 1,282 productive federal non-CBM wells are located in the BLM's Buffalo Field Office Area (BFOA). The number of non-CBM wells abandoned through 2010 is expected to exceed the number of non-CBM wells drilled during that same period (BLM 2001b). From 1985–1999, the WOGCC approved 2,851 permits for non-CBM wells. An estimated 50 percent of the wells permitted (1,397 permits) were

federal wells, and around 80 percent of the wells approved were actually drilled (BLM 2001b).

Uranium

Uranium occurs in the southern portion of the PRB, within the Tertiary (Eocene) Wasatch Formation, the Tertiary (Paleocene) Fort Union Formation, and the Cretaceous Lance Formation (Seeland 1976, Raines and Marrs 1983, Lowry et al. 1993). Uranium is present as roll-type deposits within Tertiary fluvial sandstones (Curry 1976). The following uranium districts occur within the PRB: Pumpkin Buttes; Southern Powder River; and Kaycee.

Before near-surface uranium deposits were depleted, 36,787 tons of uranium ore averaging 0.28 percent U_3O_8 were produced by 55 small surface mining operations in the Pumpkin Buttes Mining District of Campbell, Johnson, and Converse Counties during 1953–1967 (Lane et al. 1972, Breckenridge et al. 1974). Numerous prospects and abandoned uranium mines from the 1950s and 1960s remain. Uranium exploration within the PRB peaked during the 1960s and 1970s and substantial reserves were delineated deeper below the surface (Curry 1976).

More recently, uranium has been leached from subsurface deposits located in Converse and Johnson counties. However, the two in-situ leach (ISL) project operations are currently inactive.

Other Minerals

Several geologic materials occurring in the PRB are used as aggregate sources or construction materials. Clinker is produced from burned coal beds, and is widely used as a road surfacing material in the PRB. Clinker occurring in coal beds within the Fort Union Formation covers about 290 square miles of the Project Area. Clinker occurring in coal beds within the Wasatch Formation covers about 170 square miles of the Project Area (Heffern and Coates 1997). Sand and gravel are produced from terrace and alluvial deposits occurring near rivers and larger tributary streams in the PRB. Clay occurring in association with coal in the Fort Union Formation is suitable for use in brick and tile manufacturing, and has been mined in the past (Boyd et al. 1999). No estimate of existing disturbance from aggregate/construction materials quarries in the Project Area is available.

Deposits of bentonite, high-calcium limestone, and gypsum occur in Mesozoic and Paleozoic rocks exposed along the uplifted margins of the Project Area (Wolfbauer 1976, Harris and King 1989). Deposits occurring along the eastern flank of the Bighorn uplift are described by Wendell et al. (1976) and Lageson et al. (1978). These non-metallic industrial minerals are used in various industries, manufacturing, and agriculture for their chemical and physical properties. They occur stratigraphically below the geologic formations that may be affected by CBM development in the PRB.

Production of bentonite comes from surface pits in Cretaceous deposits occurring in south central Johnson County (Wendell et al. 1976). No estimate of existing disturbance from bentonite mining in the Project Area is available.

Geologic Hazards

Earthquake Hazards

The Federal Emergency Management Agency and the USGS have classified Wyoming as having a very high seismic hazard (Wyoming Water Resources Data System [WWRDS] 2001a). Magnitude 6.25 to 6.5 events can occur within the Project Area. However, the Project Area is not within the portion of Wyoming that is included in the high-risk Intermountain Seismic Belt (University of Utah 2001).

Earthquake hazards in Wyoming are summarized by (Wyoming Emergency Management Agency [WEMA] 2001b). Between 1871 and 1993, 69 earthquakes of moderate intensity have originated in Wyoming. The largest recorded earthquake in central and eastern Wyoming occurred near Casper on November 14, 1897. The magnitude of this earthquake was estimated to be between 5.0 and 5.9.

Earthquakes Induced by Injection of CBM Produced Water

Today, underground injection is strictly controlled, and occurs in an injection zone (geological formation) that is sufficiently porous and permeable that fluids can enter the rock formation without causing an excessive build-up of pressure or fracturing of rocks. An earthquake would occur when pressure is released as rocks move in the subsurface.

Underground injection has been regulated by the EPA (and by some states, on behalf of EPA,) only since 1974, when the Safe Water Drinking Act was passed. Prior to 1974 there were inadequate controls on injection wells. Many past examples exist of environmental impacts resulting from fracturing of rock layers or release of built-up pressure, caused by injection.

Flood Hazards

Most surface water in the Project Area flows in response to storm events, snowmelt, releases from reservoirs, or surface discharges of CBM produced water. Flood hazards within the Project Area can be associated with weather conditions such as intense local storm events or rapid snowmelt, CBM discharge into low-capacity stream channels, and the failure or inadequacy of human-engineered drainage or impoundment structures to retain water. Minimization of floods hazards within the Project Area is dependent upon adequate control of surface flows.

Minimization of flood damage from an intense local storm event occurring within the Project Area in 2001 has been attributed to the existence of many small reservoirs storing increased flows of CBM produced water for the beneficial use of landowners (Asssociated Press 2001). A localized storm dumped 7.5 inches of rain near Gillette in May 2001, causing much less loss than a comparable August 1985 storm event (WEMA 2001a, WEMA 2001b, Associated Press 2001).

Landslide Hazards

Landslides present in the Project Area occur in bedrock, debris, or earth, as topples, slides, spreads, flows, or a combination of these types (Case 1997, Case 2001). Landslide densities are high along the Little Powder River north of Gillette, along the Powder River in Johnson and Sheridan Counties, and in western portions of Johnson and Sheridan Counties (WWRDS 2001b). Minimization of mass movement is dependent, in part, on limiting additional disturbance to existing landslides and areas susceptible to movement.

Windblown Deposits

There are scattered occurrences of windblown sand deposits along the southeastern and eastern margins of the PRB. This type of deposit is subject to continuing migration unless stabilized by a good vegetative cover (Boyd et al. 1999).

Aquifer Collapse and Ground Subsidence

Case et al. (2000) describe the conditions present in areas where the removal of fluids from subsurface aquifers has caused subsidence and make a comparison with PRB conditions. The geologic conditions in the PRB are not the same as those observed in the cases cited below.

Where unconsolidated alluvial aquifers have collapsed in other geographic areas, due to dewatering, significant ground subsidence has occurred. In the United States, ground surface subsidence related to fluid withdrawal has been documented at a number of localities, including the San Joaquin Valley in California; Las Vegas, Nevada; New Orleans, Louisiana; and Houston, Texas. The common geological tie between these localities is that all are underlain by saturated, unconsolidated sands and gravels with interbeds and/or overlying beds of saturated clays. Water or oil is being removed (pumped) from the sands and gravels, causing ground subsidence.

In the PRB, the Fort Union Formation is a consolidated rock unit, and is not being substantially dewatered. The Fort Union Formation is only being partially dewatered to the top of the coal seam. The bedrock underlying the surface is compacted and consolidated. Instead of loose sand, sandstone is present; instead of unconsolidated clay, shale is present. However, even saturated bedrock, such as sandstone, can compress if water is removed under certain conditions.

Using a formula to estimate how much a confined aquifer may compress when water is removed, it appears that for CBM development levels analyzed in the Wyodak CBM Project EIS, minor aquifer compression up to 1/2 inch may occur in the coal beds that are being developed for coal bed methane in the Gillette area. That entire compression, however, may not be transmitted to the surface. To date, no surface subsidence has been associated with significant municipal water withdrawals in the Gillette area (Case et al. 2000, Edgar and Case 2000).

Gas Migration, Seepage, and Methane Venting

De Bruin et al. (2001) describe the conditions associated with methane migration, seepage, and venting. Methane seeps usually occur where coal beds are extremely close to the surface. Natural cracks or passageways for the gas to flow

usually do not exist where the coal is deeper. Extraction of CBM removes the gas before it flows into shallower areas.

The methane contained in Fort Union coals is present in a free state, adsorbed on interior pore surfaces and micropores of the coal matrix, and dissolved in water contained within the coal seam. Reducing the hydrostatic pressure on the coal seam by pumping off the water enhances the release and production of methane previously trapped in the coal matrix as well as gas dissolved in the water.

Methane seepage can occur naturally in the vicinity of near-surface coal seams (Glass et al. 1987, Jones et al. 1987). The potential for methane migration within the PRB is not limited to areas containing near-surface coal seams or areas where dewatering has occurred. Methane migration potentially could occur at widespread locations within the PRB, as methane can migrate long distances along naturally-occurring joints or fractures in rocks, as well as up poorly-completed wells and drill holes. If near surface coals were to burn, the introduction of methane to the outcrop area, through seepage, could intensify the natural process of combusion if the methane were to burn along with the coal.

Spontaneous Combustion of Coals

In the PRB and other regions where coal occurs at or near the surface, exposures of clinker can be associated with coal outcrops, marking the locations where coal has burned in place. Burning coal in the PRB is a natural process which has been going on ever since erosion began to expose the coal beds (Coates 1991). It has long been recognized that spontaneous combustion, range fires, and lightning, cause coal outcrops to burn naturally, producing clinker (Rogers 1918).

Lyman and Volkmer (2001) summarize the history and occurrence of coal fires in the PRB. Coal outcrop fires occurred during the Tertiary period several million years ago and have continued to the present.

Clinker outcrops are concentrated in the following areas: along the eastern boundary of the Project Area in the Rochelle Hills; within the Powder River Breaks in the northern portion of the Project Area; within the Tongue River Breaks north of Sheridan; within the Lake De Smet area north of Buffalo; and within the Felix area west of Gillette and northeast of Wright (Heffern and Coates 1997). As coal burns, the burn front advances into the hillside until, with increasing depth, fissures in deposits overlying the coal fail to reach the surface. At that point, the supply of air to the coal is cut off, extinguishing the fire (Coates and Heffern 1999, Heffern and Coates 1999).

Environmental factors contributing to the self-ignition of coals are the exposure of coals to oxygen, causing oxidation to occur and releasing heat, and the exposure of dry coals to moisture, producing heat during the wetting process. Small particles of coal have a greater surface area available for oxidation to take place and are highly susceptible to self-ignition (Lyman and Volkmer 2001).

The coals in the PRB contain reactive materials required for spontaneous combustion. However, conditions favoring the self-ignition of coal are not present in the immediate vicinity of CBM wells. Lyman and Volkmer (2001) compare the

conditions favoring spontaneous combustion of coal to conditions associated with mining and CBM development. Unlike surface coal mining, during CBM development the likelihood of completely dewatering a coal bed and exposing large areas of fine coal particles to oxygen is extremely remote. Unlike abandoned underground mines, CBM wells leave no underground voids susceptible to further subsidence and associated spontaneous coal ignition.

Lyman and Volkmer (2001) also compare conditions favoring spontaneous combustion of coal to CBM development activities in the PRB. During the production phase of CBM activity, conditions necessary to foster spontaneous combustion of coal are not present. CBM wells are designed to keep oxygen (a contaminant) out, and to maintain airflow in a direction out of the well. Any heat generated is vented to the surface before there is enough build up to result in coal ignition. The relatively small diameter of a CBM wellbore prohibits large volumes of fines from accumulating. Fines that do accumulate are flushed from the hole prior to production or during well maintenance. Faults and fractures that may be present in the overburden are sealed via casing and cement. After methane production ceases, CBM wells are plugged and sealed.

Soils

Soils within the Project Area have developed in residual material and alluvium in a climatic regime characterized by cold winters, warm summers, and low to moderate precipitation. The upland soils are derived from both residual material (derived from flat-lying, interbedded sandstone, siltstone, and shale) and stream alluvium. Valley soils have developed in unconsolidated stream sediments including silt, sand, and gravel. Soils are generally low in organic matter and are alkaline (Lowry et al., 1986). Textures range from clay loams to sandy loams with varying amounts of gravel or coarser materials. Slopes range from nearly level to very steep with deeper soils found in the less steeply sloping areas. These soils support little crop agriculture except in irrigated valleys of perennial streams. The predominant land use is rangeland. Vegetation is predominantly grass-shrub that is used for grazing and wildlife habitat.

County soil surveys have been completed in Sheridan, southern Johnson, southern Campbell, and northern Converse counties. However, county surveys are still in the preliminary mapping stages in northern Johnson and northern Campbell counties. Because of the incomplete county-level soil survey coverage and the large geographical area involved, STATSGO mapping for the state of Wyoming was used to provide generalized soils coverage for the Project Area. Although the STATSGO mapping is adequate for this level of analysis, it is insufficient for use in locating specific well pads, access roads, pipelines, and other associated facilities.

Each association in STATSGO is named for the three dominant soil series within that association. The areal extent of all STATSGO map units in the Project Area are listed in Table 3–11. Characteristics for each of these dominant soil series were identified using both the published and preliminary county soil surveys. In addition, slope data were used in combination with series data to identify areas with higher potential for water erosion.

Table 3–11 General Soils Information – Areal Extent of Soil Units

STATSGO Map Unit	Map Unit Name	Percent of Area
WY002	Midway - Samday - Rock Outcrop	0.20
WY004	Haverson - Glenberg - Bone	0.46
WY042	Cabbart - Yawdim - Hesper	0.20
WY043	Ridge - Broadus - Reeder	0.05
WY044	Havre - Hanly - Glendive	0.16
WY045	Cabbart - Yawdim - Thurlow	0.49
WY046	Cabba - Ringling - Yawdim	0.55
WY047	Draknab - Arvada - Bidman	0.41
WY048	Riverwash - Haverdad Clarkelen	2.50
WY049	Shingle - Renohill - Forkwood	8.12
WY050	Shingle - Taluce - Kishona	11.47
WY051	Wyarno - Hargreave - Moskee	0.72
WY053	Shingle – Cushman - Taluce	3.22
WY055	Haverdad - Havre - Zigweid	2.08
WY056	Samday - Shingle - Rock Outcrop	0.56
WY057	Doney - Shaak - Wayden	0.92
WY058	Abac - Peritsa - Rock Outcrop	<0.01
WY059	Rock Outcrop - Starley - Woosley	2.69
WY060	Tolman - Abac - Rock Outcrop	0.67
WY061	Agneston - Rock Outcrop - Granile	0.55
WY062	Owen Creek - Tongue River - Gateway	<0.01
WY063	Wolf - Platner - Platsher	1.48
WY064	Plashter - Recluse - Parmleed	0.99
WY065	Baux - Bauxson - Harlan	2.50
WY066	Moskee - Hargreave - Shingle	1.20
WY078	Frisco - Troutville - Teewinot	0.04
WY081	Barnum - Haverdad - Rock Outcrop	0.40
WY082	Reno - Shingle - Parmleed	8.17
WY084	Keyner - Samday - Rock Outcrop	1.93
WY085	Samday - Badland - Rock Outcrop	0.81
WY086	Cambria - Shingle - Kishona	1.44
WY087	Shingle - Cambria - Renohill	0.83
WY088	Sunup - Rock Outcrop - Spearfish	1.55
WY114	Tassel - Turnercrest - Terro	0.01
WY115	Shingle - Samday - Absted	0.21
WY124	Plashter - Kishona - Hiland	1.98
WY125	Shingle - Theedle - Wibaux	2.40
WY126	Hiland - Vonalee - Maysdorf	4.27
WY127	Kishona - Shingle - Theedle	4.10
WY128	Renohill - Cushman - Cambria	3.15
WY129	Bidman – Parmleed - Renohill	2.70
WY130	Renohill - Bidman - Ulm	6.29
WY203	Clarkelen - Draknab - Haverdad	0.25
WY204	Hiland - Ustic Torriorthents - Bowbac	1.50
WY205	Dwyer - Orpha - Hiland	0.61
WY206	Wibaux - Rock Outcrop - Shingle	1.40
WY207	Hiland - Bowbac - Tassel	3.02

Table 3–11 General Soils Information – Areal Extent of Soil Units

STATSGO Map Unit	Map Unit Name	Percent of Area
WY208	Shingle - Samday - Hiland	1.53
WY209	Hiland - Shingle - Tassel	5.52
WY210	Ulm - Renohill - Shingle	1.33
WY211	Shingle - Tassel - Rock Outcrop	1.74
WY315	Rock Outcrop - Hazton - Redsun	0.20
WY316	Hiland - Bowbac - Keyner	<0.01
WY317	Shingle - Taluce - Amodac	0.10
WY321	Hiland - Orpha - Bowbac	0.08
WY322	Roughlock - Rock Outcrop - Rekop	0.08
WY323	Lolite - Hiland - Vonalee	0.01
WY324	Hiland - Forkwood - Zigweid	0.11
WY325	Lolite - Rock Outcrop - Keyner	0.06
WYW	Surface Water	0.02

Soil Descriptions

Appendix F lists the dominant soil series for all the associations in the Project Area. For each series, the general characteristics of the soil are listed. Series with severe wind and water erosion hazards, high compaction potential (based on high shrink-swell capacity), high salinity, soils with a poor revegetation potential, and prime or otherwise valuable agricultural soils are marked in the table. A brief description of each parameter in the table follows this discussion.

"Rock Outcrop" is listed numerous times in Table 3–11 as one of the three predominant soil types in the series. Though the nature of this outcrop is not described in county soil surveys, the "Rock Outcrop" notation refers to exposed bedrock or a formation known as clinker. Clinker, also referred to as "scoria", is rock that has been baked by subsurface coal fires and has migrated to the surface. This baked rock is highly resistant to erosion and as a result, clinker is often found atop plateaus and ridges in the Powder River Basin. The Geology section (beginning on page 3–31) describes clinker concentrations in the Project Area in more detail.

Generally, clinker consists of fractured rock on a base of porous ash. Semipermeable clay frequently underlies clinker formations (Heffern and Coates, 1999). This structure allows clinker to absorb, store, and transfer large amounts of water. The quality of water from clinker aquifers is highly variable but in general, TDS values are lower for older formations (Heffern and Coates, 1999). The irregular terrain of clinker formations provides a unique habitat for plant and animals species that would otherwise not survive on the treeless plain (Heffern and Coates, 1999). Clinker is not considered a valuable agricultural soil and has a very poor revegetation potential. Rock outcrop soil types that do not refer to clinker are most likely exposed sandstone, shale, or other bedrock. Like clinker, this exposed bedrock has poor revegetation potential, but provides valuable wildlife habitat.

Wind Erosion Hazard

Severe wind erosion hazards were identified by determining the wind erosion group for each soil. These groups are based on soil texture (grain size, parent material, cohesiveness, wetness, etc.), and indicate how susceptible a soil is to wind erosion. Nine groupings have been developed (1, 2, 3, 4, 4L, 5, 6, 7, 8), the lower the number, the greater the risk of wind erosion. Group 1 includes soils that consist entirely of fine sand, which is highly susceptible to wind erosion, and Group 8 contains very wet or stony soils, which are not at all subject to wind erosion. Soils listed in Groups 1 and 2 were considered Severe Hazards for this section.

Severe wind erosion hazards primarily run down the center of Campbell County from the Wyoming-Montana border to about 14 miles south of Gillette and along the Little Powder River. These soils cover much of Converse County as well (Figure 3–6).

Slope Hazards

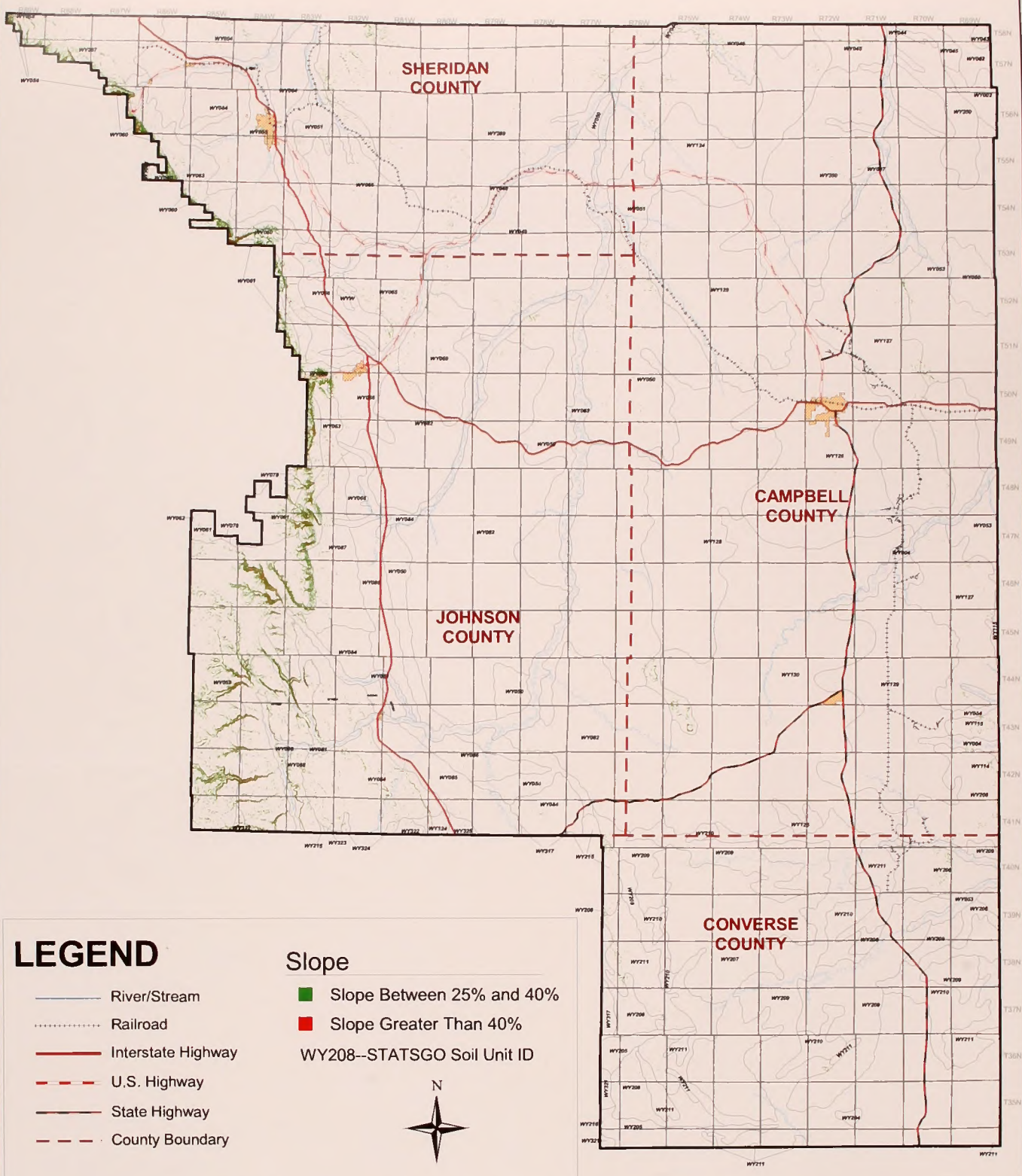
A soil's stability is greatly affected by the slope on which it occurs. In general, the greater the slope, the greater the potential for slumping, landslides and water erosion. Slope ranges used to identify slope hazards were determined by the USDA National Soil Survey Handbook and appropriate COAs. For this analysis, slopes from 0 to 25 percent are considered minimal hazards, 25 to 40 percent slopes are moderate, and slopes 40 and above are considered severe hazards. Hazards for minimal slopes have been further broken down in the Water Erosion Hazard Section. These ranges are quite general and the exact stability and susceptibility to water erosion depends greatly on each soil's characteristics.

Severe and moderate slope hazards in the Project Area occur primarily along the southwest corner of the Project Area in Johnson County (Figure 3–6). Small areas of these slope hazards are scattered throughout the Project Area as well.

Water Erosion Hazard

Severe water erosion hazards were identified using permeability classes, K-factor, and slope. Slopes above from 25 to 40 percent are considered moderate water erosion hazards and slopes 40 percent and above are considered severe water erosion hazards.

As so much of the Project Area falls within the 25 percent and below slope range, permeability class and K-factor for each soil type were used to determine which soils might be more susceptible to water erosion on gentle topography. At slopes less than 5 percent, only the least permeable and highest K-factor soils (neither of which occur in the Powder River Basin) are susceptible to water erosion. At slopes greater than 25 percent, only the most permeable and lowest K-factor soils (neither of which occur in the Powder River Basin) are not susceptible to water erosion (U.S. Department of Agriculture, Soil Conservation Service 1994).



LEGEND

- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

Slope

- Slope Between 25% and 40%
- Slope Greater Than 40%

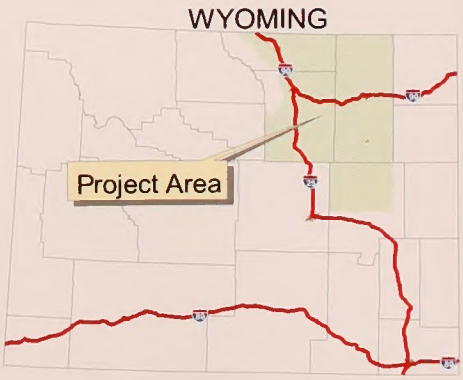
WY208--STATSGO Soil Unit ID

N

Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 3-6 SOILS AND SLOPE	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_v1\data\maps.apr Layout--Soils Slope
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

LEGEND

Water erosion hazards for soils on slopes between 5 percent and 25 percent were identified with permeability classes and K-factors. Soil permeability classes were determined by infiltration rates in inches per hour. Rates from 0 to 0.2 in/hr were considered slow, 0.2 through 6.0 inches/hour moderate and 6.0 in/hr and greater were considered rapid. Generally, primarily sandy soils had the greatest infiltration rates, while clayey soils had very slow infiltration rates.

K–factor is one of six factors used in the Universal Soil Loss Equation to predict annual rate of soil loss due to water erosion. Soil structure, percentage of silt, sand, and organic matter, and permeability all affect the K-factor of a soil (U.S. Department of Agriculture, Natural Resources Conservation Service [NRCS] 1986a,b,c). Values for K range from 0.02 to 0.69. The higher value, the more susceptible the soil is to water erosion. Soils with low permeability and high K–factors were determined to be severe water erosion hazards for slope ranges between 5 percent and 25 percent (SCS 1994).

Severe and moderate water erosion hazards (based on the 25 to 40 percent and 40 percent and above slope ranges) in the Project Area occur primarily along the southwest corner of the Project Area in Johnson County. Soils with severe water erosion potential in the five to 25 percent slope range occur along the northern and eastern borders of the Project Area and extend down the center of the Project Area along the Powder River and into Converse County.

Compaction/Shrink-Swell Potential

Compaction and shrink-swell potential affect a soil's ability to support construction and to be reclaimed. Both characteristics are related to the amount of clay in a soil. A soil with a high clay content is very compactable and has a high shrink-swell potential. Clay grains are extremely small and can be forced so closely together that few pore spaces remain. Thus, most air and water is pushed out of the soil. In addition, the soil grains may become so tightly compacted that plants roots would not be able to penetrate the soil. Due to the absence of air and water and the difficulty of root growth, reclamation of a tightly compacted clay soil is extremely difficult without loosening the soil prior to seeding.

Shrink-swell potential is the potential for volume change in a soil with a gain or loss in moisture. Like compaction, a soil's shrink-swell potential is determined partially by its clay content. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to capacity. A change of 3 percent is considered low, 3-6 percent is moderate and a change of greater than 6 percent is classified as high. In soils with a high shrink-swell potential, rapid changes in volume can damage structures and roads (NRCS 1986a,b,c). Soils classified as high shrink-swell potential in the county soil survey are marked as severe hazards in this section.

Severe shrink-swell potential soils occur along the northern and western borders of the Project Area and on either side of the Powder River, down the center of Sheridan and Johnson Counties and the eastern portion of Campbell County. The

entire south half of Campbell County and small, widely separated portions of Converse County are dominated by these soils also.

Salinity

The SAR, or sodicity, of surface water and groundwater and salinity of soils are important chemical characteristics due to their effects on plant life and soils productivity. SAR is the ratio of the concentration of sodium ions relative to calcium and magnesium ions in water. Salinity is a measure of soluble salts in the soil, measured as conductivity in millimhos per centimeter at 25°C (mmhos/centimeters). SAR can only be measured in water, whereas salinity can be measured in both soil and water. Salinity detracts from a plant's ability to take in water, whereas sodicity slows the movement of water through the soil.

Plant roots exclude salt from the water they extract from the soil. In highly saline water, a plant must expend significant energy to take in water. This expenditure diverts energy from growth and reproduction, reducing the productivity of the plant. Soils with salinity levels from 0 to 8 mmhos/centimeters are considered slightly saline, soils with levels of 8 to 16 mmhos/centimeters are considered moderately saline and soils with salinity levels above 16 mmhos/centimeters are considered strongly saline.

Sodium is attracted to clay particles and will fill pore spaces in the soil, restricting the movement of water through the soil. As clays have much smaller pore spaces and greater attraction to sodium than any other soil constituent, a water with a high SAR value affects clayey soils faster than coarser soil types. SAR values between 10 and 15 are considered high. SAR levels in surface water are discussed in more detail in the sections on Surface Water quality (beginning on page 3–23).

Salinity in soils can be affected by the SAR in surface water and the duration of exposure to that water. Consequently, the salinity of soils can change rapidly over time and can differ greatly between similar soils types depending on the quality of the local water and the irrigation program. Additionally, any soil that is poorly drained, like clay, has flat slopes, impermeable bedrocks, or is flooded frequently, could retain water and concentrate salts.

Small sections of the Project Area concentrated near the confluence of the Powder River and the South Fork of the Powder River and along the Bell Fourche River, Black Thunder and Little Black Thunder creeks are classified as high salinity. The saline soils in these areas most likely occupy toe slopes, alluvial fans, and stream terraces. Soils near or downstream from coal mines have also been found to be highly saline (Tidball and Ebens, 1976). These statements are very general possible locatios for saline soils. Chemical characteristics in soils can vary greatly over a large geographic area, regardless of soil type.

Poor Revegetation Potential

Soils with poor revegetation potential were determined using the land capability classification given in the county soil surveys. Soils are grouped according to

their limitations for field crops, the risk of damage if used for agriculture, and response to management. Capability classes are divided into eight groups (Roman Numerals I–VIII), with Class I soils having few limitations and Class VII soils having multiple limitations that prevent commercial crop production. Class VII and Class VIII soils were determined have poor revegetation potential for this analysis.

Soils with poor revegetation potential occur throughout the Project Area, except the central portion of Campbell County.

Prime Agricultural Soils

Prime soils were identified by the Wyoming state office of the NRCS. Sheridan County, Converse County and the central section of Campbell County are covered extensively by prime agricultural soils. Additionally, these soils extend into Johnson County along the Powder River and Clear Creek.

Air Quality and Climate

The air quality of any region is controlled primarily by the magnitude and distribution of pollutant emissions and the regional climate. The transport of pollutants from specific source areas is strongly affected by local topography. In the mountainous western United States, topography is particularly important in channeling pollutants along valleys, creating upslope and downslope circulations that may entrain airborne pollutants, and blocking the flow of pollutants toward certain areas. In general, local effects are superimposed on the general synoptic weather regime and are most important when the large-scale wind flow is weak.

Topography

The Project Area is located in the southern portion of the PRB of the northwestern Great Plains Steppe in northeastern Wyoming. The Great Plains Steppe is a large physiographic province extending throughout most of eastern Wyoming, Montana and Colorado, as well as portions of western North and South Dakota, Nebraska, Kansas, and the Oklahoma panhandle. The topography of the Project Area varies from moderately steep to steep mountains and canyons in the western portions, to rolling plains and tablelands of moderate relief (with occasional valleys, canyons and buttes) in the eastern regions. Elevations generally range from about 3,000 to 5,000 feet above mean sea level, with mountain peaks rising to over 10,000 feet west of the Project Area.

Climate and Meteorology

Because of the variation in elevation and topography throughout the Project Area, climatic conditions vary considerably. Most of the area is classified as a semi-arid cool steppe, where evaporation exceeds precipitation, with relatively short warm summers and longer cold winters. On the plains, average daily temperatures typically range from 5 to 10 (low) and 30 to 35 (high) degrees Fahrenheit (°F) in mid-winter, and between 55 to 60 (low) and 80 to 85 (high) degrees

Fahrenheit in mid-summer. The frost-free period (at 32°F) generally occurs for 120 days between late May and mid-September. The annual average total precipitation is nearly 12 to 16 inches, with 36 to 60 inches of total annual snowfall. Temperatures generally are cooler, frost-free periods shorter, and both precipitation and snowfall greater at the higher elevations, including the mountains along the western margin of the Project Area.

Prevailing winds occur from the southwest, but local wind conditions reflect channeling (mountain and valley flows) due to complex terrain. Nighttime cooling enhances stable air, inhibiting air pollutant mixing and transport along the valley drainages. Dispersion potential improves along ridge and mountain tops, especially during winter-spring weather transition periods and summer convective heating periods. Given the lack of representative wind measurements throughout the Project Area, regional wind speed and direction values for air quality modeling were derived from the MM4 (mesoscale model) and CALMET meteorological models (Argonne 2001).

Existing Air Quality

Although specific air quality monitoring is not conducted throughout most of the Project Area, air quality conditions in rural areas are likely to be very good, as characterized by limited air pollution emission sources (few industrial facilities and residential emissions in the relatively small communities and isolated ranches) and good atmospheric dispersion conditions, resulting in relatively low air pollutant concentrations. Occasional high concentrations of carbon monoxide (CO) and particulate matter may occur in more urbanized areas (e.g. Buffalo, Gillette, and Sheridan) and around industrial facilities, especially under stable atmospheric conditions common during winter.

Anticipated contributors to pollutant levels within the region include the following:

- exhaust emissions (primarily carbon monoxide and oxides of nitrogen [NO_x]) from existing natural gas fired compressor engines used in production of natural gas; gasoline and diesel vehicle tailpipe emissions of combustion pollutants (Volatile Organic Compounds [VOC], CO, NO_x, inhalable particulate matter less than 10 microns in effective diameter [PM_{10}], fine particulate matter less than 2.5 microns in effective diameter [$PM_{2.5}$], and sulfur dioxide [SO_2]);
- dust (particulate matter) generated by vehicle travel on unpaved roads and windblown dust from neighboring areas and road sanding during the winter months;
- transport of air pollutants from emission sources located outside the region;
- dust from coal mines; and
- SO_2 and NO_x from power plants.

As part of the analysis, monitoring data obtained throughout the northeastern Wyoming and southeastern Montana were assembled and reviewed. Although monitoring is primarily conducted in urban or industrial areas, the data are con-

sidered the best available representation of background concentrations of air pollutants throughout the Project Area. These values are presented in Table 3–13, along with applicable ambient air quality standards and Prevention of Significant Deterioration (PSD) increments, and were used to define background conditions for the analysis of effects to air quality. The assumed background pollutant concentrations are below applicable National Ambient Air Quality Standards (NAAQS) and Wyoming Ambient Air Quality Standards for most pollutants and averaging times, although monitored hourly background concentrations of NO_x, ozone and SO_2 are not available.

Air Quality Related Values — Visibility and Acidification of Lakes

Air Quality Related Values (AQRVs), including the potential effects of air pollutant on visibility and the acidification of lakes and streams, are applied to PSD Class I areas. The land management agency responsible for the Class I area sets each AQRV as the level of acceptable change (LAC). The AQRVs reflect the land management agency's policy and are not treated as legally enforceable standards.

Visibility

Potential impacts to visibility were considered at 16 PSD Class I and Class II areas near the PRB region. Table 3–12 shows the nearest distances from the sensitive receptor areas to the proposed project area.

Table 3–12 Distances from the Project Area to PSD Class I and Class II Sensitive Receptor Areas

Receptor Area	PSD Class	Distance (miles)
Badlands National Park		112
Bridger Wilderness Area	I	152
Fitzpatrick Wilderness Areas		147
N. Absaroka Wilderness Area		118
N. Cheyenne Reservation		25
Washakie Wilderness Area		117
Wind Cave National Park		81
Agate Fossil Beds National Monument		102
Big Horn Canyon National Recreation Area	II	51
Black Elk Wilderness Area		81
Cloud Peak Wilderness Area		13
Devil's Tower National Monument		36
Fort Laramie National Historic Site		90
Jewel Cave National Monument		67
Mt. Rushmore National Monument		85
Soldier Creek Wilderness Area		99

Table 3–13 Assumed Background Air Pollutant Concentrations, Applicable Ambient Air Quality Standards, and PSD Increment Values (in µg/m3)

Pollutant	Averaging Time[1]	Background Concentration	Primary NAAQS[2]	Secondary NAAQS[2]	Wyoming Standards	PSD Class I Increments	PSD Class II Increments
Carbon monoxide[3]	1-hour	3,500	40,000	40,000	40,000	-----	-----
	8-hour	1,500	10,000	10,000	10,000	-----	-----
Nitrogen dioxide[4]	Annual	16.5	100	100	100	2.5	25
Ozone[5]	1-hour	n/a[6]	235	235	157	-----	-----
	8-hour	130	157	157	-----	-----	-----
PM_{10}[4]	24-hour	42	150	150	150	8	30
	Annual	17	50	50	50	4	17
$PM_{2.5}$[4]	24-hour	19	65	65	65	-----	-----
	Annual	7.6	15	15	15	-----	-----
Sulfur dioxide[7]	3-hour	8	-----	1,300	1,300	25	512
	24-hour	8	365	-----	260	5	91
	Annual	3	80	-----	60	2	20

Notes:
1. Annual standards are not to be exceeded; short-term standards are not to be exceeded more than once per year.
2. Primary standards are designed to protect public health; secondary standards are designed to protect public welfare.
3. per Riley Ridge EIS (BLM 1993)
4. Data collected in Gillette, WY (1996 - 1997, and 1999)
5. Data collected in Pinedale, WY (1992 - 1994)
6. n/a = not available
7. Data collected at Devil's Tower, WY (1983)

Source: (Argonne 2001)

Visibility can be defined as the distance one can see and the ability to perceive color, contrast, and detail. Fine particulate matter ($PM_{2.5}$) is the main cause of visibility impairment. Visual range, one of several ways to express visibility, is the furthest distance a person can see a landscape feature. Maximum visual range in the western United States would be about 140 miles. Presently, the best-monitored visibility in the United States is in the Bridger Wilderness Area. Visual range monitoring in the Bridger Wilderness Area shows that one can see more than 70 miles 70 percent of the time.

Visibility impairment is expressed in terms of deciview (dV). The deciview index was developed as a linear perceived visual change. A change in visibility of 1.0 dV represents a "just noticeable change" by the average person under most circumstances. Increasing dV values represent proportionately larger perceived visibility impairment. Figure 3–7 and Figure 3–8 below show average annual visibility at Badlands National Park and Bridger Wilderness from 1988 to 1998, respectively.

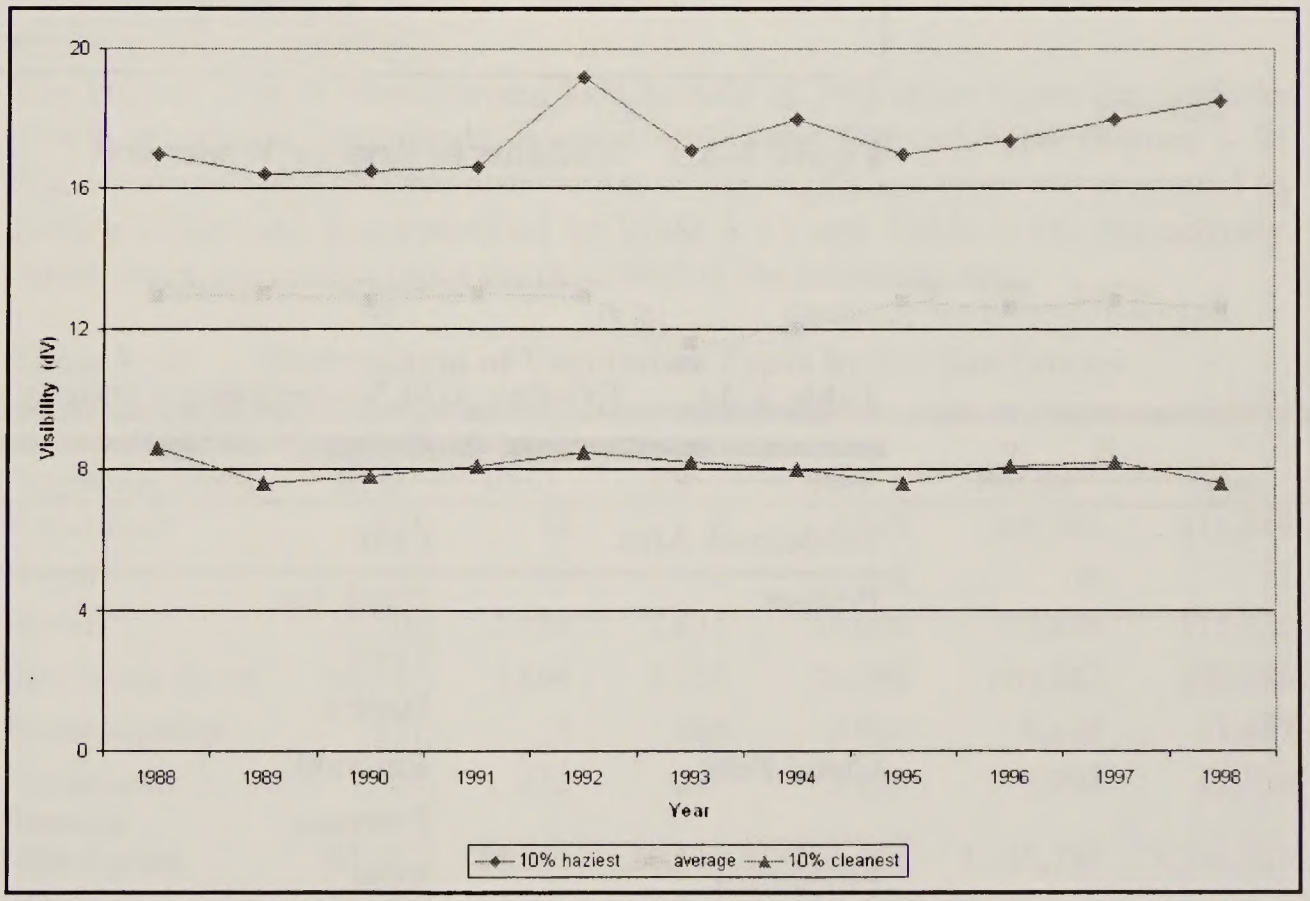


Figure 3–7 Visibility in the Badlands National Park

Acidification of Lakes

The acidification of lakes and streams is caused by atmospheric deposition of pollutants (acid rain). Lake acidification is expressed as the change in acid neutralizing capacity (ANC), the lake's capacity to resist acidification from acid rain. Table 3–14 shows the existing ANC monitored in mountain lakes within the study area.

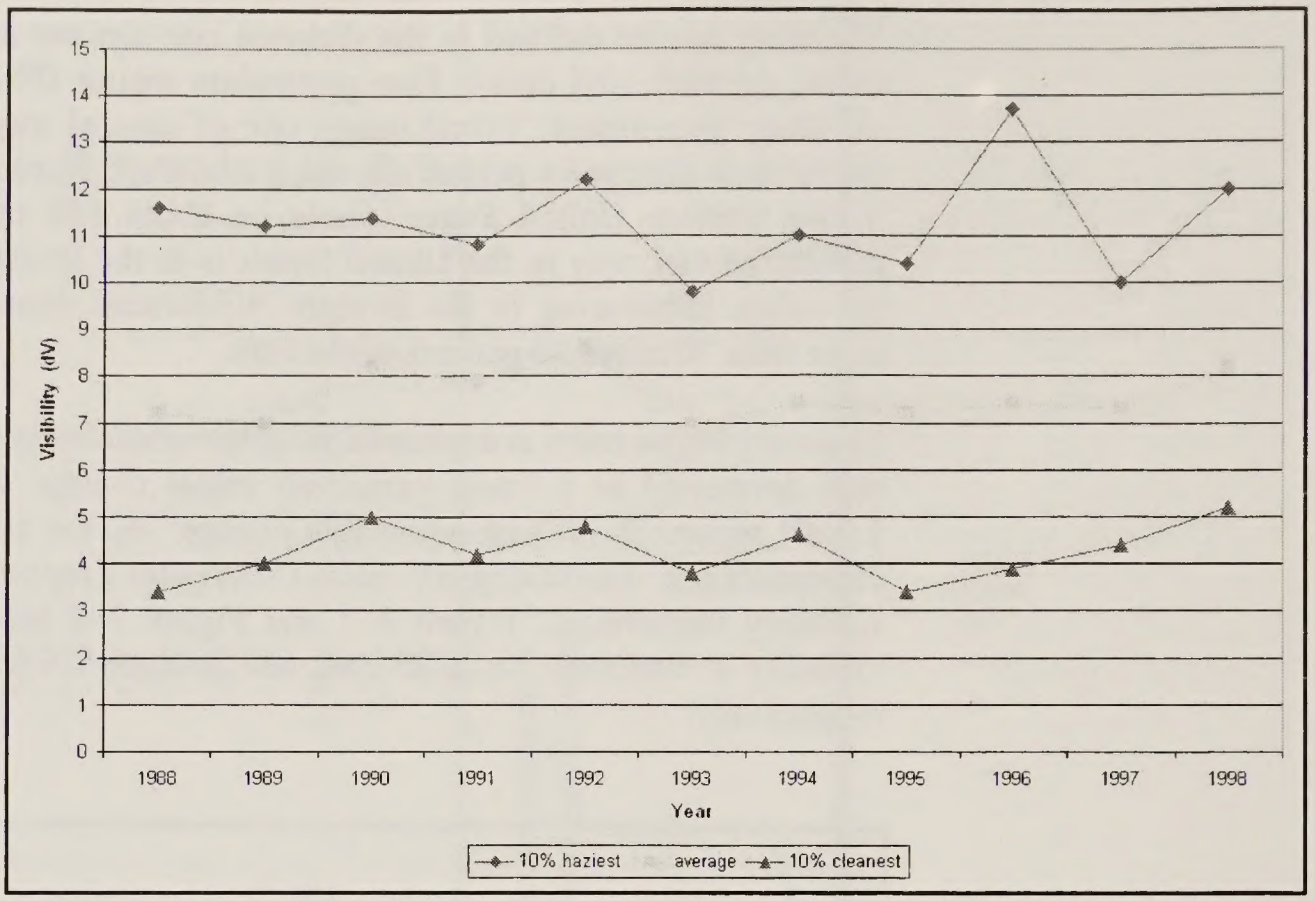


Figure 3–8 Visibility in Bridger Wilderness

Table 3–14 Existing Acid Neutralizing Capacity in Sensitive Lakes

Wilderness Area	Lake	Background ANC (μeq/L)
Bridger	Black Joe	69.0
	Deep	61.0
	Hobbs	68.0
Cloud Peak	Emerald	55.3
	Florence	32.7
Fitzpatrick	Ross	61.4
Popo Agie	Lower Saddlebag	55.5

Regulatory Framework

The National and Wyoming Ambient Air Quality Standards set the absolute upper limits for specific air pollutant concentrations at all locations where the public has access. Existing air quality throughout most of the Project Area is in attainment with all ambient air quality standards, as demonstrated by the relatively low concentration levels presented in Table 3–13. However, the Sheridan, Wyoming area has been designated as Federal non-attainment area (PM_{10} – moderate) where the applicable standards have been violated in the past.

Mandatory Federal Class I areas were designated by the U.S. Congress on August 7, 1977, and include wilderness areas greater than 5,000 acres in size and national parks greater than 6,000 acres in size. In addition, the Northern Cheyenne Tribe (located north of the Project Area in Montana) has re-designated their lands as PSD Class I. The allowable incremental impacts for NO_2, PM_{10}, and SO_2 within these PSD Class I areas are very limited. Most of the Project Area is designated as PSD Class II with less stringent requirements.

Vegetation and Land Cover Types

WGFD land cover classifications mapping and Gap Analysis Project (GAP) resources were used to identify vegetation types within the Project Area. Fourteen vegetation types were identified within the Project Area: short-grass prairie, mixed-grass prairie, wet meadow, herbaceous riparian, sagebrush shrubland, other shrubland, shrubby riparian, coniferous forest, aspen, forested riparian, agriculture, urban/disturbed, barren, and water. These broad categories often represent several vegetation types that were similar in terms of dominant species and ecological importance.

The Project Area is characterized as a mosaic of vegetation types that includes prairie grasslands, shrublands, riparian areas, and forested areas (Figure 3–9). The occurrence and relative distribution of the vegetation types are presented by surface owner and sub-watershed in Table 3–15 and Table 3–16, respectively. These major vegetation types are described in the following text.

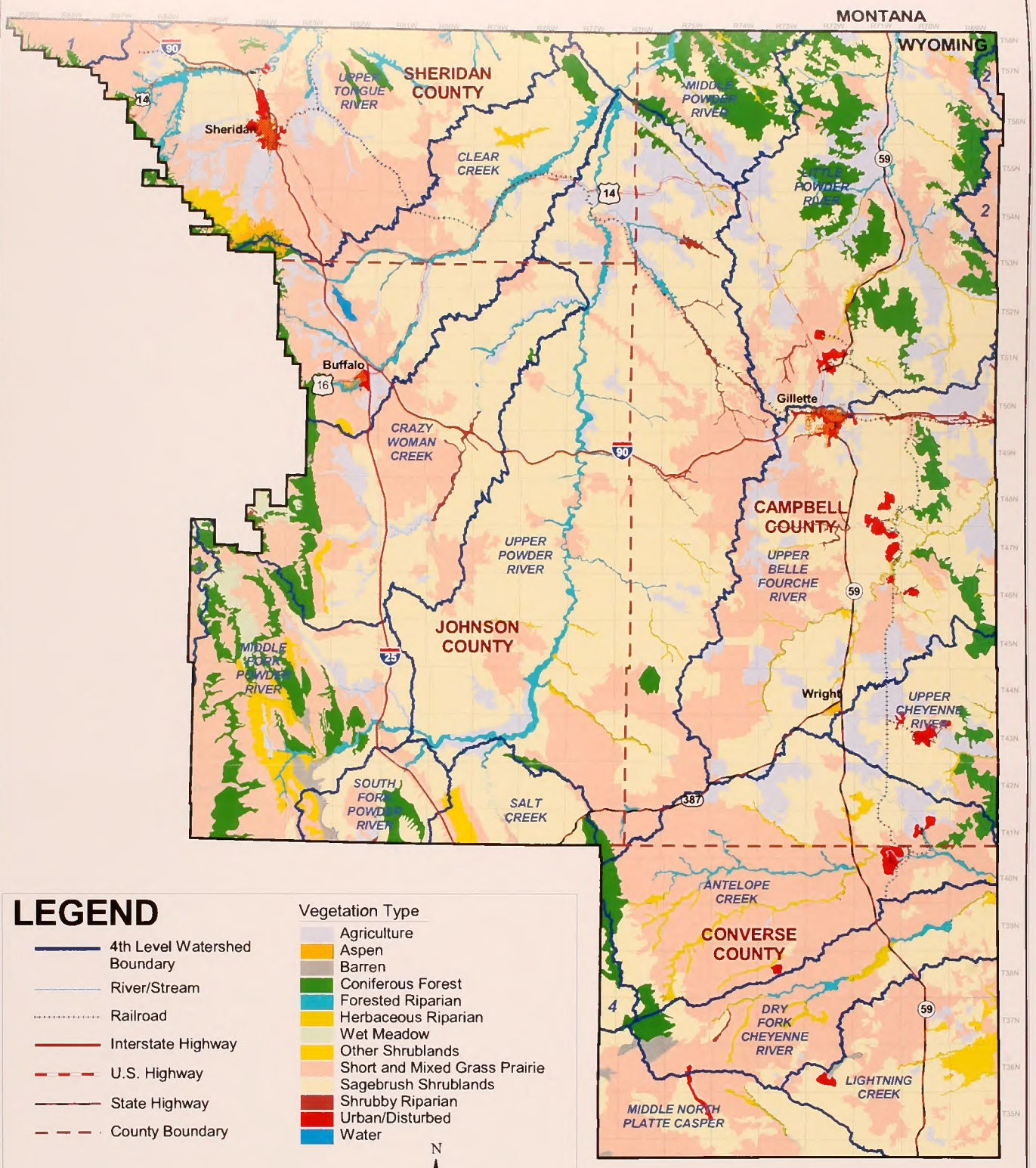
Table 3–15 Distribution of Vegetation Types by Surface Owner

Vegetation Type	BLM		FS	State	Private	Total
	BFO	CFO				
Agriculture	231	18	0	4,729	108,666	113,644
Aspen	0	0	0	2	69	71
Barren	18,104	2,886	2,631	19,034	72,870	115,525
Coniferous Forest	46,442	5,804	5,553	29,050	105,337	192,186
Forest Riparian	251	0	285	2,930	8,026	11,492
Herbaceous Riparian	26	413	617	3,298	7,984	12,338
Mixed-grass Prairie	91,202	25,251	28,519	261,006	1,142,551	1,548,529
Other Shrublands	51,952	1,605	262	26,923	97,141	177,883
Sagebrush Shrublands	187,969	27,287	85,627	279,488	1,653,758	2,234,129
Shortgrass Prairie	399,087	27,741	149,871	434,409	2,262,781	3,273,889
Shrubby Riparian	734	32	90	5,879	52,183	58,918
Urban/Disturbed	0	0	0	34	4,328	4,362
Water	242	29	121	519	8,279	9,190
Wet Meadow	1,521	0	553	27,365	129,500	158,939
Total	797,761	91,066	274,129	1,094,666	5,653,473	7,911,095

Table 3–16 Distribution of Vegetation Types by Sub-watershed

Sub-watershed	Vegetation Type														
	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	683	0	0	4,497	601	0	22,088	190	4,331	1,094	10,607	0	44	5,450	49,585
Upper Tongue River	59,055	12	4,122	15,269	3,172	67	303,684	538	119,744	124,205	32,931	0	1,106	75,987	739,892
Middle Fork Powder River	584	3	16,300	50,711	1,767	5	107,781	106,069	61,805	117,615	173	0	202	1,441	464,456
North Fork Powder River	0	0	0	3,060	1,628	0	8,583	643	4,788	109	0	0	0	1,864	20,675
Upper Powder River	5,958	0	25,153	6,715	0	0	108,275	13	424,952	1,020,649	582	0	1,385	9,857	1,603,539
South Fork Powder River	1	0	1,803	2,545	48	0	24,745	30,090	12,255	42,725	0	0	145	0	114,357
Salt Creek	0	0	186	3,563	0	0	3,892	779	42,589	101,204	0	0	148	0	152,361
Crazy Woman Creek	8,567	56	9,114	33,127	636	46	112,692	15,892	124,134	237,519	1,059	0	426	5,021	548,289
Clear Creek	27,184	0	4,754	11,510	1,033	41	170,382	1,799	128,220	156,874	9,347	0	3,607	32,732	547,483
Middle Powder River	1,143	0	3,265	10,637	0	0	72,552	0	47,363	81,889	547	0	0	6,836	224,232
Little Powder River	998	0	9,447	26,103	0	0	172,186	0	375,460	267,553	1,750	0	636	11,359	865,492
Little Missouri River	320	0	144	567	0	0	20,842	0	7,174	5,853	550	0	0	3,078	38,528
Antelope Creek	398	0	5,096	6,750	948	0	15,337	387	124,619	506,341	0	0	430	0	660,306
Dry Fork Cheyenne River	795	0	8,828	9,040	1,518	5,198	105,619	1,340	58,899	116,899	771	384	29	0	309,320
Upper Cheyenne River	108	0	2,771	4,477	141	114	6,147	0	87,730	104,631	169	0	419	99	206,806
Lightning Creek	7,086	0	2,093	0	0	4,263	95,125	20,143	166,207	11,710	0	1,698	0	0	308,325
Upper Belle Fourche River	764	0	18,302	3,355	0	0	85,963	0	353,210	377,019	432	0	613	5,215	844,873
Middle North Platte Casper	0	0	4,147	260	0	2,604	112,636	0	90,649	0	0	2,280	0	0	212,576
Total	113,644	71	115,525	192,186	11,492	12,338	1,548,529	177,883	2,234,129	3,273,889	58,918	4,362	9,190	158,939	7,911,095

Source: BLM 2001e



LEGEND

- 4th Level Watershed Boundary
- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

Vegetation Type

- Agriculture
- Aspen
- Barren
- Coniferous Forest
- Forested Riparian
- Herbaceous Riparian
- Wet Meadow
- Other Shrublands
- Short and Mixed Grass Prairie
- Sagebrush Shrublands
- Shrubby Riparian
- Urban/Disturbed
- Water

N

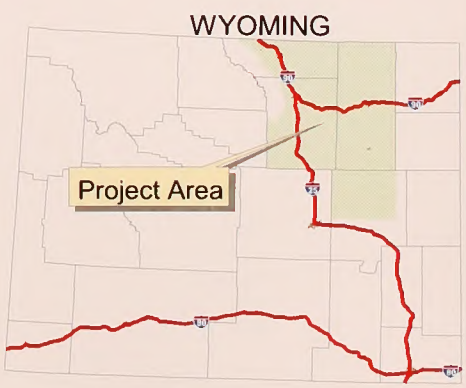
Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek

Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers



POWDER RIVER BASIN OIL & GAS EIS

FIGURE 3-9
DISTRIBUTION OF VEGETATION TYPES WITHIN THE PROJECT AREA

ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_v1\data\gap_veg.apr Layout--Gap Veg
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

LEGEND

Short-grass Prairie

The short-grass prairie vegetation type accounts for 3,273,889 pre-disturbance acres (41 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and by surface owner within the Project Area. This vegetation type represents very sparse, sparse, and thin dry herbaceous rangeland types, as defined by the WGFD.

Short-grass prairie occurs on drought-prone, mildly alkaline, medium and fine-textured soils. Few shrubs grow consistently in short-grass prairie because the soils are too dry and compacted to support them. Precipitation is an important determinant of the plant species composition in grasslands. Average annual precipitation for short-grass prairie is between 10 and 16 inches (CNAP 1998). In Wyoming, short-grass prairie occurs primarily in the southeastern portion of the state and southward into Colorado. Within the Project Area, short-grass prairie habitats are most common in the south, occurring as the dominant plant community from the southern foothills of the Bighorn Mountains to the eastern Project Area boundary. Plant species common to the short-grass prairie include blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), western wheatgrass (*Pascopyrum smithii*), sand dropseed (*Sporobolus cryptandrus*), needle-and-thread (*Stipa comata*), scarlet globemallow (*Sphaeralcea coccinea*), and fourwing saltbush (*Atriplex canescens*).

Mixed-grass Prairie

The mixed-grass prairie vegetation type accounts for 1,548,529 pre-disturbance acres (19 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This vegetation type is a combination of low, medium, and high herbaceous rangeland types, as defined by WGFD.

Mixed-grass prairie can be divided into several types and is characterized by several common species including needle-and-thread, western wheatgrass, blue grama, pricklypear cactus (*Opuntia compressa*), and scarlet globemallow. Wyoming big sagebrush (*Artemisia tridentat* var. *Wyomingensis*) is a common shrub of this grass community in the Powder River Basin (Knight 1994). Within the Project Area, mixed-grass prairie habitats are most common along the eastern foothills of the Bighorn Mountains and sporadically occur throughout much of the northern and central portions of the Project Area.

Wet Meadow

The wet meadow vegetation type accounts for 158,939 pre-disturbance acres (2 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This vegetation type is a combination of green and very green herbaceous rangeland types, as defined by WGFD.

Wet meadow is a grassland community that typically occurs where the water table is high enough to saturate the soil during a portion of the growing season. This community commonly occurs along reservoirs, springs, and irrigated pastures. Depending upon salinity and water table, common species include woolly

sedge (*Carex laneuginosa*), common spike-rush (*Eleocharis palustris*), arctic rush (*Juncus arcteicus*), foxtail barley (*Hordeum jubatum*), and Canada goldenrod (*Solidago canadensis*) (CNAP 1998). Within the Project Area, wet meadow habitats are widely distributed and often insular in their occurrence. Although these habitats occur throughout the Project Area, wet meadows are more common in the north and west than in the south and east portions of the Project Area. Wet meadows tend to exist as island habitats surrounded by dominant plant communities such as grasslands or shrublands.

Herbaceous Riparian

The herbaceous riparian vegetation type accounts for 12,338 pre-disturbance acres (<1 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This vegetation type consists of a variety of riparian moist grasses, sedges, and rushes, as defined by WGFD.

The herbaceous riparian vegetation type includes species common to the wet meadow community, however, this vegetation type occurs near drainages including rivers, streams, and creeks. Common plant species may include woolly sedge, common spike-rush, foxtail barley, wild licorice (*Glycyrrhiza lepidota*), and Canada goldenrod. Very similar to the wet meadow community, this vegetation cover type often occurs in similar environments and supports similar plant species. Herbaceous riparian communities occur throughout the Project Area with most occurrences associated with streams, rivers, and other aquatic habitats.

Sagebrush Shrubland

The sagebrush shrubland vegetation type accounts for 2,234,129 pre-disturbance acres (28 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This vegetation type is the combination of sparse, moderately dense, and dense big sagebrush crown closure. A variety of understory grasses and forbs can occur as understory in this vegetation type.

The big sagebrush is widely distributed and occupies a large proportion of the Project Area. Plant species that typically occur in this community may include Wyoming big sagebrush, silver sagebrush (*Artemisia cana*), western wheatgrass, junegrass (*Koeleria macrantha*), needle-and-thread grass, Sandberg bluegrass (*Sandberg bluegrass*), pricklypear cactus, scarlet globemallow, and rabbitbrush (*Chrysothamnus* spp.) (Knight 1994). Sagebrush shrublands occur throughout the entire Project Area, with the Bighorn Mountains and associated foothills as the only exceptions. Although common in the southern portions of the Project Area, larger more contiguous tracts of sagebrush occur in the northeastern, central, and eastern portions of the Project Area.

Other Shrubland

The other shrubland vegetation type accounts for 177,883 pre-disturbance acres (2 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This vegetation category is comprised of shrub/grass mix, greasewood

(*Sarcobatus vermiculatus*), rabbitbrush, mountain mahogany (*Cercocarpus* spp.), and bur oak (*Quercus macrocarpa*), as defined by WGFD. This vegetation cover type is relatively uncommon and occurs primarily in the southwest corner of the Project Area.

Riparian Shrubby

The riparian shrubland vegetation type accounts for 58,918 pre-disturbance acres (<1 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This vegetation category includes a variety of shrubs and herbaceous plants existing adjacent to draws, gullies, and streams. Within the Project Area, plant species occurring in this community may include hawthorn (*Crataegus* spp.), chokecherry (*Prunus virginiana*), peachleaf willow (*Salix amygdaloides*), sandbar willow (*Salix exigua*), and other willow species (*Salix* spp.). This vegetation type occurs in small scattered locations throughout the Project Area.

Coniferous Forest

The coniferous forest vegetation type accounts for 192,186 pre-disturbance acres (2 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This vegetation type includes Englemann spruce (*Picea engelmannii*), Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta* var. *latifolia*), ponderosa pine (*Pinus ponderosa*), limber pine (*Pinus flexilis*), and juniper (*Juniperus* spp.), as defined by WGFD. These species tend to form associations based upon elevation, exposure, and soil moisture. Typically, these species are segregated according to elevation. Juniper and pine forests tend to be lower in elevation while spruce and fir forests occur at higher elevations. This vegetation type occurs primarily along the western edge of the Project Area, where the upper elevation conifer species are more common and in the northeastern corner where the lower elevation species are more common.

Aspen

The aspen vegetation type accounts for 71 pre-disturbance acres (<1 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. Aspen communities typically occur in depressions, ravines, valley bottoms, or on the lee sides of wedges. Aspen are intolerant of drier conditions, and therefore their distribution is typically dictated by soil moisture availability. Small areas of conifers may also occur in this vegetation type. This vegetation type is limited to the Bighorn Mountains in the Project Area.

Forested Riparian

The forested riparian vegetation type accounts for 11,492 pre-disturbance acres (<1 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This vegetation type is characterized by a variety of deciduous and coniferous tree species that occur along riparian areas, as defined by WGFD. Some of these species include plains cottonwood (*Populus deltoides*), narrow-leaf cotton-

wood (*Populus angustifolia*), quaking aspen (*Populus tremuloides*), boxelder (*Acer negundo*), ash (*Fraxinus pennsylvanica*), Russian olive (*Elaeagnus angustifolia*), and willow (*Salix* spp). This vegetation type occurs along the major drainages throughout the Project Area.

Agriculture

The agricultural vegetation type accounts for 113,644 pre-disturbance acres (<1 percent) with the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This land cover type is defined as croplands that are plowed and/or planted. These areas may also include wooded or shrubby draws and riparian areas. Agricultural areas are most common along the eastern edge of the Bighorn mountains, along the major drainages, and in the vicinity of Wright and Gillette.

Urban/Disturbed

The urban/disturbed vegetation type accounts for 4,362 pre-disturbance acres (<1 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This cover type includes lands covered by homes, businesses, streets, and unvegetated surface mining areas. It is most common around cities and towns and along the eastern edge of the Project Area where many coal mines are located.

Barren

The barren vegetation type accounts for 115,525 pre-disturbance acres (<1 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This cover type includes rock outcrops, roads, sandbars, eroded gullies, and areas with less than ten percent ground cover and perennial snow and ice areas, as defined by WGFD. It occurs as small, scattered areas throughout the Project Area, and as several large blocks in the southwest portion.

Water

The water cover type accounts for 9,190 pre-disturbance acres (<1 percent) within the Project Area. Table 3–15 and Table 3–16 present the relative distribution among the sub-watersheds and surface owners within the Project Area. This land cover type includes lakes, ponds, streams, and open water in wetlands, as defined by WGFD, and is scattered throughout the Project Area.

Noxious Weeds

Once established, non-native plant species can out compete and eventually replace native species, thereby reducing forage productivity and the overall vigor of existing native plant communities. As a consequence of these effects, many non-native species are viewed as detrimental to the environment, and are regulated as such. A designated noxious weed is defined by the Wyoming Department of Agriculture as seeds or other plant parts that are considered detrimental, destructive, injurious or poisonous, either by virtue of their direct effect or as carriers of diseases or parasites that exist within this state, and are on the designated

list. The State of Wyoming has designated twenty-two plant species as noxious weeds. These species are listed in Table 3–17.

Table 3–17 State of Wyoming Designated Noxious Weeds

Common Name	Scientific Name	Common Name	Scientific Name
Russian knapweed	*Acroptilon repens*	Quackgrass	*Elytrigia repens*
Skeletonleaf bursage	*Ambrosia tomentosa*	Leafy Spurge	*Enphorbia esula*
Common burdock	*Arctium minus*	Dyer's woad	*Isatis tinctoria*
Hoary cress	*Cardaria draba*	Perennial pepperweed	*Lepidium latifolium*
Plumeless thistle	*Carduus acanthoides*	Ox-eye daisy	*Leucanthemum vulgare*
Musk thistle	*Carduus nutans*	Dalmation toadflax	*Linaria dalmatica*
Diffuse knapweed	*Centaurea diffusa*	Yellow toadflax	*Linaria vulgaris*
Spotted knapweed	*Centaurea maculosa*	Purple loosestrife	*Lythrum salicaria*
Canada thistle	*Cirsium arvense*	Scotch thistle	*Onopordum acanthium*
Field Bindweed	*Convolvulus arvensis*	Perennial sowthistle	*Sonchus arvensis*
Houndstongue	*Cynoglossum officinale*	Saltcedar	*Tamarix chinensis*

Source: Wyoming Weed and Pest Council 2001.

In addition to the state noxious weed list, Campbell, Converse, Johnson, and Sheridan counties have identified other noxious weeds of concern. Noxious weeds tracked by counties within the Project Area include cocklebur (*Xanthium strumarium*), chicory (*Cichorium intybus*), Dames rocket (*Hesperis matronalis*), and common mullein (*Verbascum thapsus*).

Wyoming is experiencing the rapid introduction and spread of noxious weeds throughout the state on all lands, regardless of surface ownership. The potential for noxious weeds to continue spreading to new areas is great. As a collaborative effort, the BLM, South Goshen Cooperative Extension Conservation District, Wyoming Department of Agriculture, Natural Resources Conservation Service, and 42 private surface owners joined WGFD and Weed and Pest (W&P) District officials in the fight against noxious weeds. This group agreed to a long-term integrated weed management plan, public awareness and prevention programs, and a common inventory, while monitoring and reporting on their progress.

Noxious weeds are expected to occur throughout the Project Area. Their occurrence, distribution, and density are variable and influenced by many factors including disturbance type and frequency, climatic conditions, soil conditions, and local management efforts. Other than lists of noxious weeds maintained by the State of Wyoming and several counties, there are no additional scientific data that indicate precise areas of occurrence of any individual weed species, or noxious weeds as a whole.

Existing Disturbance

Because of past human activities in the Project Area, substantial areas of vegetation have been altered from their natural condition. Some of these alterations are included in the previous discussion of vegetation types, particularly in the agri-

culture and barren land cover types. Other human disturbances are typically smaller in scale and are not included in the analysis of the Project Area vegetation types. Examples of these types of disturbances include: roads, oil and gas well pads, compressor sites, and other ancillary facilities. At the time of this analysis, estimates of current disturbances related to these ancillary facilities were not available by vegetation type.

The following estimates of existing disturbances are based on the sum of existing CBM and non-CBM well disturbances within the Project Area. Estimates of existing disturbance acreage in each vegetation type by surface owner and subwatershed are presented in Table 3–18 and Table 3–19, respectively.

Table 3–18 Existing Vegetation Disturbance by Surface Owner

	Areal Extent of Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	0	0	0	40	648	688
Aspen	0	0	0	0	0	0
Barren	44	0	14	70	877	1,005
Coniferous Forest	89	0	17	28	127	261
Forest Riparian	0	0	6	0	6	12
Herbaceous Riparian	0	0	0	6	33	39
Mixed Grass Prairie	168	44	50	1,228	10,321	11,811
Other Shrublands	32	4	148	0	84	268
Sagebrush Shrublands	287	55	582	3,488	23,170	27,582
Shortgrass Prairie	908	83	919	4,062	27,034	33,006
Shrubby Riparian	0	0	0	11	182	193
Urban/Disturbed	0	0	0	0	0	0
Water	0	0	0	0	64	64
Wet Meadow	6	0	0	155	1,549	1,710
Total	1,534	186	1,736	9,088	64,095	76,639

Wetlands/Riparian Areas

Regional Characterization

Wetlands and riparian areas are unique features in the landscape occurring where aspects of soil, vegetation, and hydrology combine to form specially adapted plant communities. Due to the arid nature of the majority of the Project Area, these areas are typically restricted to major drainages, creeks, draws, lakes, and ponds. Significant water systems in the Project Area include Lake Desmet, Upper Powder River, Upper Tongue River, Upper Belle Fourche River, Clear Creek, Crazy Woman Creek, and the Upper Cheyenne River.

Table 3–19 Existing Vegetation Disturbance by Sub-watershed

Sub-watershed	Vegetation Type (acres)														
	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	306	0	193	0	0	0	1,035	0	966	1,231	130	0	21	372	4,254
Middle Fork Powder River	0	0	11	0	0	0	0	63	6	94	0	0	0	0	174
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	132	0	145	16	0	0	1,702	0	3,666	6,373	3	0	6	343	12,386
South Fork Powder River	0	0	0	61	0	0	6	81	28	0	0	0	0	0	176
Salt Creek	0	0	0	0	0	0	0	0	44	209	0	0	0	0	253
Crazy Woman Creek	0	0	0	0	0	0	69	0	308	370	0	0	0	0	747
Clear Creek	139	0	13	0	0	0	572	0	292	275	11	0	0	267	1,569
Middle Powder River	36	0	43	77	0	0	1,025	0	723	1,403	20	0	0	252	3,579
Little Powder River	46	0	161	69	0	0	3,792	0	8,369	5,336	9	0	18	322	18,122
Little Missouri River	0	0	0	0	0	0	61	0	0	11	6	0	0	6	84
Antelope Creek	6	0	22	17	12	0	139	0	1,771	5,738	0	0	0	0	7,705
Dry Fork Cheyenne River	0	0	28	0	0	17	193	0	226	149	0	0	0	0	613
Upper Cheyenne River	0	0	21	0	0	0	49	0	987	983	0	0	0	0	2,040
Lightning Creek	6	0	11	0	0	22	798	124	1,172	6	0	0	0	0	2,139
Upper Belle Fourche River	17	0	357	21	0	0	2,295	0	9,013	10,828	14	0	19	148	22,712
Middle North Platte Casper	0	0	0	0	0	0	75	0	11	0	0	0	0	0	86
Total	688	0	1,005	261	12	39	11,811	268	27,582	33,006	193	0	64	1,710	76,639

Riparian Areas

Riparian areas "develop in transitional zones between permanently saturated wetlands and upland areas. These areas exhibit vegetation or physical characteristics reflective of permanent surface or subsurface water influence" (Leonard et al. 1992). The vegetation that visually defines a riparian area is valuable in providing sediment retention, flood-flow attenuation, nutrient removal and transformation, increased production (relative to uplands) for livestock and wildlife forage, habitat diversity for aquatic terrestrial wildlife, and streambank stability. Their occurrence is generally associated with areas of flowing water. Riparian areas are an important resource on public lands and are managed as such (Almand and Krohn 1978; BLM 1991). Although riparian areas often contain wetlands, they also may contain areas that do not meet federal definitions of jurisdictional wetlands. Likewise, not all wetland areas are associated with riparian ecosystems. Table 3–15 and Table 3–16 present the occurrence and relative distribution of riparian areas in the Project Area.

Wetlands

Wetlands are landscape features that are delineated on the basis of specific soil, vegetation, and hydrologic conditions. A wetland is defined as an area typically flooded or saturated with sufficient frequency and/or duration, with surface water or groundwater, that these areas mostly support vegetation adapted for growth in soils that are saturated under normal circumstances (40 Code of Federal Regulations [CFR] 230). Wetlands typically include swamps, marshes, bogs, and similar areas. Waters of the U.S. is a collective term for all areas subject to regulation by the U.S. Army Corps of Engineers (COE) under Section 404 of the Clean Water Act. Waters of the U.S. within the Project Area may include: intermittent and ephemeral draws, creeks, and rivers. As the result of the recent Supreme Court ruling (Solid Waste Agency of Northern Cook County *v.* United States Army Corps of Engineers, January 9, 2001) non-navigable, isolated intrastate wetlands and other Waters of the U.S. within the Project Area are not considered jurisdictional. Navigable, non-isolated wetlands and other Waters of the U.S. are still considered jurisdictional by the COE.

Wetlands can occur in a variety of forms within the Project Area. Riverine wetlands, defined by their close association with perennial streams, occur sporadically along drainages within the Project Area. These areas are supported not only by the groundwater associated with the drainage, but by periodic flooding events. Common species in these settings can include willows (*Salix* spp.), scouring rush (*Equisetum* spp.), sedges (*Carex* spp.), and rushes (*Juncus* spp.) (FS 1987).

Topographical depressions that are naturally subirrigated support palustrine wetlands. Palustrine wetlands are commonly referred to as wet meadows and can support a variety of lush plant life. Lacustrine wetlands can also occur in topographical depressions. Naturally occurring lacustrine wetlands are often referred to as playa lakes. Conditions similar to those found in playa lakes can also be created by man-made structures such as stock ponds. Common plant species that can occur in these depressional wetlands include cattails (*Typha* spp.), bulrush (*Scirpus* spp.), sedges, rushes, cordgrass (*Spartina* spp.), mint (*Mentha* spp.), butter-

cup (*Ranunculus* spp.), lady's thumb (*Polygonum* spp.), verbena (*Verbena* spp.), and milkweed (*Asclepias* spp) (Pruiett 1998; FS 1987). Table 3–15 and Table 3–16 present the occurrence and relative distribution of riparian areas in the Project Area drainages; wetlands within the Project Area are assumed to be a portion of the riparian areas shown in these tables.

Wildlife

Regional Characterization

The wildlife species identified as part of the issues in the scoping process that inhabit the study area represent the following groups: big game, raptors, upland game birds, and waterfowl. Aquatic resources in the Project Area occur within major drainage systems, such as rivers, streams, minor creeks, draws, and playa lakes, and ponds. The following sections present information regarding the major wildlife groups common to terrestrial and aquatic environments in the Project Area.

Terrestrial Species

Wildlife Habitats

All of the vegetation types listed in the vegetation section provide habitat for some wildlife species. In an undisturbed condition, the major vegetation types in the Project Area provide high quality habitats for many wildlife species. Because these habitats tend to occur in a mosaic across the landscape, many wildlife species can be expected to utilize more than one habitat. The following paragraphs list some of the wildlife species that can be found in the common vegetation types in the Project Area, although these species may also be found in other habitat types if the necessary habitat components are available.

Common wildlife species that typically occur in shortgrass and mixed-grass prairie habitats include prairie rattlesnake (*Crotalus viridis*), golden eagle (*Asguila chrysaetos*), prairie falcon (*Falco mexicanus*), ferruginous hawk (*Buteo regalis*), Swainson's hawk (*Buteo swainsoni*), lark bunting (*Calamospiza melanocorys*), horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), lark sparrow (*Chondestes grammacus*), vesper sparrow (*Pooecetes gramineus*), badger (*Taxidea taxus*), coyote (*Canis latrans*), swift fox (*Vulpes velox*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), black-tailed jackrabbit (*Lepus californicus*), Ord's kangaroo rat (*Dipodomys ordii*), deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), plains pocket gopher (*Geomys bursarius*), black-tailed prairie dog (*Cynomys ludovicianus*), and pronghorn (*Antilocapra americana*).

Common wildlife species that may occur in sagebrush shrublands include: eastern short-horned lizard (*Phrynosoma douglassi brevirostre*), prairie rattlesnake, northern harrier, Swainson's hawk, sage grouse (*Centrocercus urophasianus*), Say's phoebe (*Sayornis saya*), western kingbird (*Tyrannus verticalis*), horned lark, sage thrasher (*Oreoscoptes montanus*), Brewer's sparrow (*Spizella breweri*),

vesper sparrow, sage sparrow (*Amphispiza belli*), McCown's longspur (*Calcarius mccownii*), western meadowlark, desert cottontail (*Sylvilagus auduboni*), black-tailed jackrabbit, thirteen-lined ground squirrel, northern pocket gopher (*Thomomys talpoides*), Ord's kangaroo rat, deer mouse, and prairie vole (*Microtus ochrogaster*).

Common wildlife species that may occur in other shrublands are similar to those that inhabit sagebrush shrublands, and include: garter snake (*Thamnophis elegans*), chukar (*Alectoris chukar*), sharp-tailed grouse (*Tympanuchus phasianellus*), western kingbird, horned lark, black-billed magpie (*Pica pica*), rock wren (*Salpinctes obsoletus*), sage thrasher, lazuli bunting (*Passerina amoena*), spotted towhee (*Pipilo maculates*), Brewer's sparrow, lark sparrow, lark bunting, bobolink (*Dolichonyx oryzivorus*), masked shrew (*Sorex cinereus*), desert cottontail, least chipmunk (*Tamias minimus*), Wyoming ground squirrel (*Spermophilus elegans*), thirteen-lined ground squirrel, deer mouse, northern grasshopper mouse (*Onychomys leucogaster*), coyote, western spotted skunk (*Spilogale gracilis*), and mule deer (*Odocoileus hemionus*).

Wildlife species that may occur in riparian areas (including herbaceous, shrubby, and forested riparian areas) include: bullsnake (*Pituophis catenifer*), tiger salamander (*Ambystoma tigrinum*), northern leopard frog (*Rana pipiens*), northern harrier (*Circus cyaneus*),Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), common snipe (*Gallinago gallinago*), short-eared owl (*Asio flammeus*), marsh wren (*Cistothorus palustris*), common yellowthroat (*Geothlypis trichas*), savannah sparrow (*Passerculus sandwhichensis*), song sparrow (*Melopsiza melodia*), red-winged blackbird (*Agelaius phoeniceus*), yellow-headed blackbird (*Xanthocephalus xanthocephalus*), deer mouse, meadow vole (*Microtus pennsylvanicus*), and red fox (*Vulpes vulpes*). Wet meadows tend to provide habitats for wildlife species associated with nearby dominant vegetation cover types (such as prairie or sagebrush shrublands), although in areas of large wet meadow complexes species common to riparian habitats may also occur.

Although they occur only sporadically throughout the Project Area, coniferous woodlands support a different set of wildlife species than other habitat types, primarily due to seed production and potential nest substrates provided by the various conifer species. Common wildlife species in coniferous forest include: mountain chickadee (*Parus gambeli*), mourning dove (*Zenaida macroura*), golden eagle, mountain bluebird (*Sialia currucoides*), northern flicker (*Colaptes auratus*), western tanager (*Piranga ludoviciana*), pinyon jay (*Gymnorhinus cyanocephalus*), chipping sparrow (*Spizella passerina*), lark sparrow, Nuttall's cottontail (*Sylvilagus nuttallii*), mule deer, gray fox (*Urocyon cinereoargenteus*), black-tailed jackrabbit, porcupine (*Erethizon dorsatum*), bushy-tailed woodrat (*Neotoma cinerea*), and mountain lion (*Felis concolor*).

Big Game

Big game species that are expected to occur in suitable habitats throughout the Project Area include pronghorn (*Antilocapra americana*), white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and moose (*Alces alces*). Nomenclature follows Jones et al. (1997).

WGFD has identified various ranges for big game species. These ranges are defined as:

- Crucial Range (CRU): any particular seasonal range or habitat component, but describes that component which has been documented as the determining factor in a population's ability to maintain and reproduce itself at a certain level.
- Summer or Spring-Summer-Fall (SSF): A population or portion of a population of animals use the documented habitats within this range annually from the end of previous winter to the onset of persistent winter conditions.
- Severe Winter Relief (SWR): A documented survival range which may or may not be considered a crucial range area as defined above. It is used to a great extent, only in occasionally extremely severe winters. It may lack habitat characteristics that would make it attractive or capable of supporting major portions of the population during normal years but is used by and allows at least a significant portion of the population to survive the occasional extremely severe winter.
- Winter (WIN): A population or portion of a population of animals use the documented suitable habitat sites within this range annually, in substantial numbers only during the winter period.
- Winter/Yearlong (WYL): A population or a portion of a population of animals makes general use of the documented suitable habitat sites within this range on a year-round basis. During the winter months there is a significant influx of additional animals into the area form other seasonal ranges.
- Yearlong (YRL): A population or substantial portion of a population of animals makes general use of the suitable documented habitat sites within the range on a year-round basis. Animals may leave the area under severe conditions on occasion.
- Parturition Areas (PAR): Documented birthing areas commonly used by females. It includes calving areas, fawning areas and lambing grounds. These areas may be used as nurseries by some big game species.

Pronghorn

Pronghorn typically inhabit grasslands and semi-desert shrublands of the western and southwestern United States. This species is most abundant in short- and mixed-grass habitats and is less abundant in more xeric habitats. Home range for pronghorn can vary between 400 acres to 5,600 acres, according to several factors including season, habitat quality, population characteristics, and local livestock occurrence. Typically, daily movement does not exceed six miles. Pronghorn make seasonal migrations between summer and winter habitats, but are often triggered by availability of succulent plants and not local weather conditions (Fitzgerald et al. 1994). Wyoming supports the largest population of pronghorn in North America (Clark and Stromberg 1987).

WGFD has delineated pronghorn into herd units to estimate population sizes. The following herd units reside entirely or partially within the Project area: 308, 309, 310, 316, 318, 339, 351, 352, 353, 354, 742, 747, and 748.

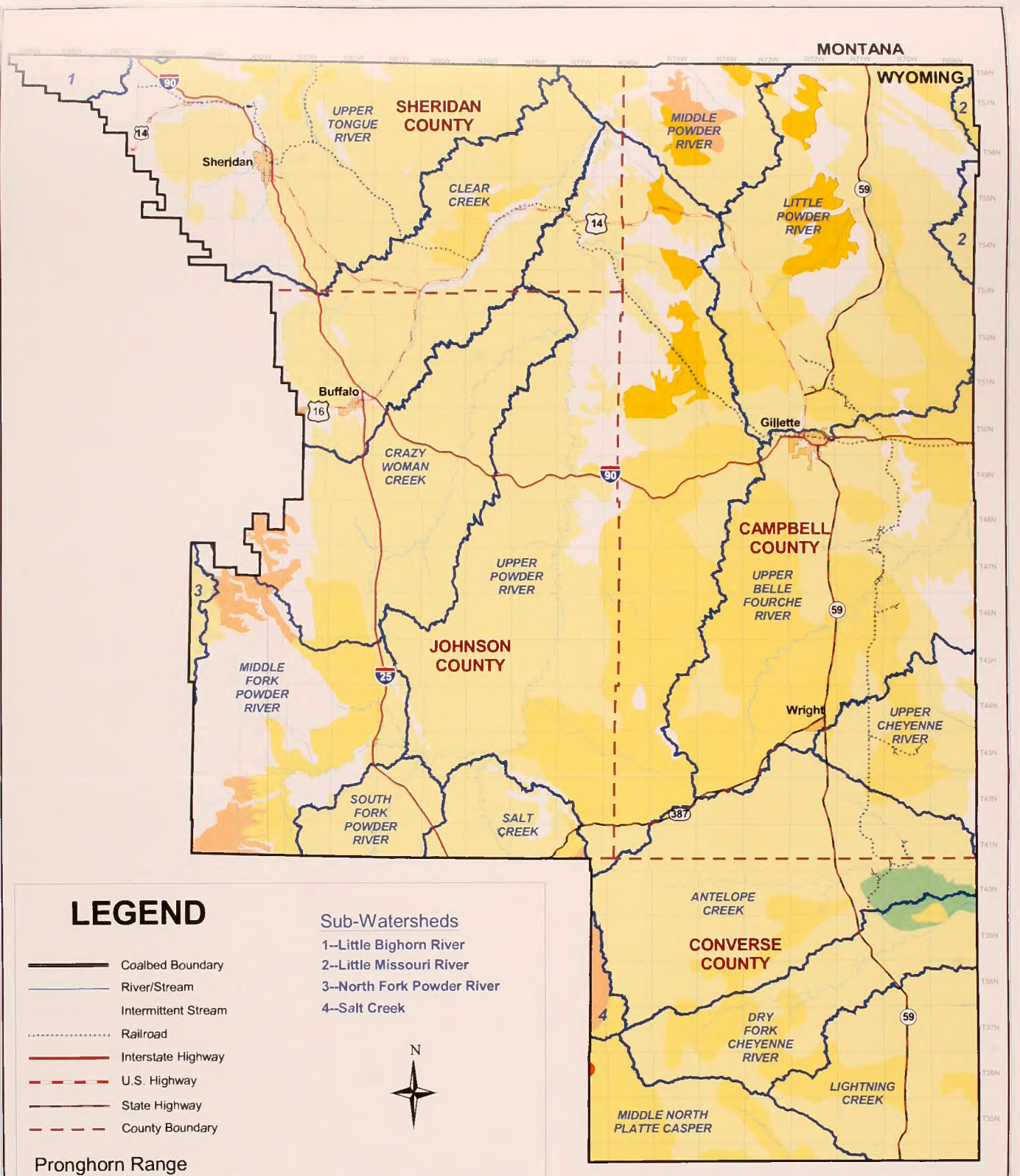
Pronghorn antelope occur in most areas throughout the Project Area, except in the foothills in the western margin of the central portion of the Project Area (Figure 3–10). The type and distribution of pronghorn ranges by land ownership and sub-watersheds are presented in Table 3–20 and Table 3–21, respectively. Figure 3–10 depicts pronghorn ranges within the Project Area. Existing human disturbances within the Project Area, as previously discussed, have altered many of the habitats used by pronghorn.

Table 3–20 Pronghorn Ranges by Surface Owner

	BLM					
Range	Buffalo Field Office	Casper Field Office	Forest Service	State	Private	Total
Severe Winter	0	0	33,590	3,197	14,181	50,968
Crucial Winter Yearlong	0	77	0	0	68	145
Winter	22,563	0	0	11,815	122,583	156,961
Winter Yearlong	97,239	39,897	37,230	131,058	1,488,113	1,793,537
Yearlong	385,467	46,550	195,488	405,163	3,643,583	4,676,250
Spring, Summer, Fall	28,023	7,359	0	14,357	73,738	123,477
Total	533,292	93,883	266,308	565,590	5,342,266	6,801,338

Table 3–21 Pronghorn Ranges by Sub-watershed

	Pronghorn Ranges (acres)						
Sub-watershed	Severe Winter	Crucial Winter	Winter	Winter Yearlong	Yearlong	Spring, Summer, Fall	Total
Little Bighorn River	0	0	0	0	1,010	0	1,010
Upper Tongue River	0	0	0	13,095	527,241	0	540,336
Middle Fork Powder River	0	0	0	118,113	42,363	59,888	220,364
North Fork Powder River	0	0	0	0	18,285	801	19,086
Upper Powder River	0	0	23,728	470,784	854,525	132	1,349,169
South Fork Powder River	0	0	0	57	114,153	0	114,210
Salt Creek	0	0	0	17,866	104,144	17,816	139,826
Crazy Woman Creek	0	0	0	36,566	446,038	18,580	501,184
Clear Creek	0	0	0	37,931	442,750	1,196	481,878
Middle Powder River	0	0	67,048	0	124,445	24,841	216,334
Little Powder River	0	0	66,185	218,720	446,055	0	730,960
Little Missouri River	0	0	0	6,406	27,559	0	33,964
Antelope Creek	31,773	0	0	57,525	570,722	222	660,242
Dry Fork Cheyenne River	19,195	0	0	83,173	206,951	0	309,320
Upper Cheyenne River	0	0	0	62,976	115,764	0	178,740
Lightning Creek	0	0	0	58,831	249,494	0	308,325
Upper Belle Fourche River	0	0	0	491,029	292,788	0	783,817
Middle North Platte Casper	0	145	0	120,467	91,964	0	212,576
Total	50,968	145	156,961	1,793,539	4,676,251	123,476	6,801,341



LEGEND

- Coalbed Boundary
- River/Stream
- Intermittent Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek

N

Pronghorn Range

- Crucial Winter Yearlong
- Spring, Summer, Fall
- Winter
- Winter Yearlong
- Yearlong
- Severe Winter Range

Scale 1 : 775,000

10 0 10 20 30 Miles

10 0 10 20 30 40 Kilometers



Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 3-10
PRONGHORN RANGES

ANALYSIS AREA:	Campbell, Converse, Johnson & Sheridan Counties, Wyoming
DATE: 12/26/01	ArcView File: C:\1011 v1\data\maps.apr Layout--Pronghorn
	DRAWN BY: MSH


LEGEND

WGFD has estimated the population size all of herd units within the Project Area to be 108,802 (Rothwell 2001). This number excludes data from herd units 742 and 747, which were unavailable.

The overall population trend of pronghorn in the Project area has increased and stabilized. In general, herd units have reached WGFD population objectives. As of 2000, the average herd unit population is 26.2 percent above the population objective (Rothwell 2001).

Because of past human activities in the Project Area, substantial areas of pronghorn ranges have been altered from their natural conditions. Human disturbances include, but are not limited to agriculture, mining, roads, urban areas, oil and gas well pads, compressor sites, and other aneillary facilities. Table 3–22 and Table 3–23 present existing disturbance to pronghorn ranges by owner and sub-watershed, respectively.

Table 3–22 Existing Pronghorn Disturbance by Surface Owner

	Surface Owners (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Severe Winter	0	0	60	10	70	140
Winter	149	0	0	497	2,196	2,841
Winter Yearlong	544	100	757	4,194	38,125	43,721
Yearlong	1,294	240	1,895	7,685	47,985	59,099
Spring, Summer, Fall	128	0	0	116	355	599
Total	2,115	340	2,712	12,502	88,731	106,400

White-tailed Deer

White-tailed deer occur throughout North America from the southern United States to the Hudson Bay in Canada. Across much of its range, this species utilizes forests, swamps, brushy areas, and nearby open fields. In Wyoming, the white-tailed deer are found throughout the state typically coneentrated in riparian woodlands, shrubby riparian and associated irrigated agrieultural lands and absent from dry grasslands and coniferous forests (Clark and Stromberg 1987). Their diet is diverse, capitalizing on the most nutritious plant matter available at any particular time. In addition to native browse, grass, and forbs, this species will rely on agricultural crops, fruits, aeorns and other nuts. White-tailed deer mortality is typieally due to hunting, winter starvation, collisions with automobiles, and predation. Predators may include eoyotes, mountain lions, wolves, and, occasionally, bears, bobeats and eagles (Fitzgerald et al. 1994).

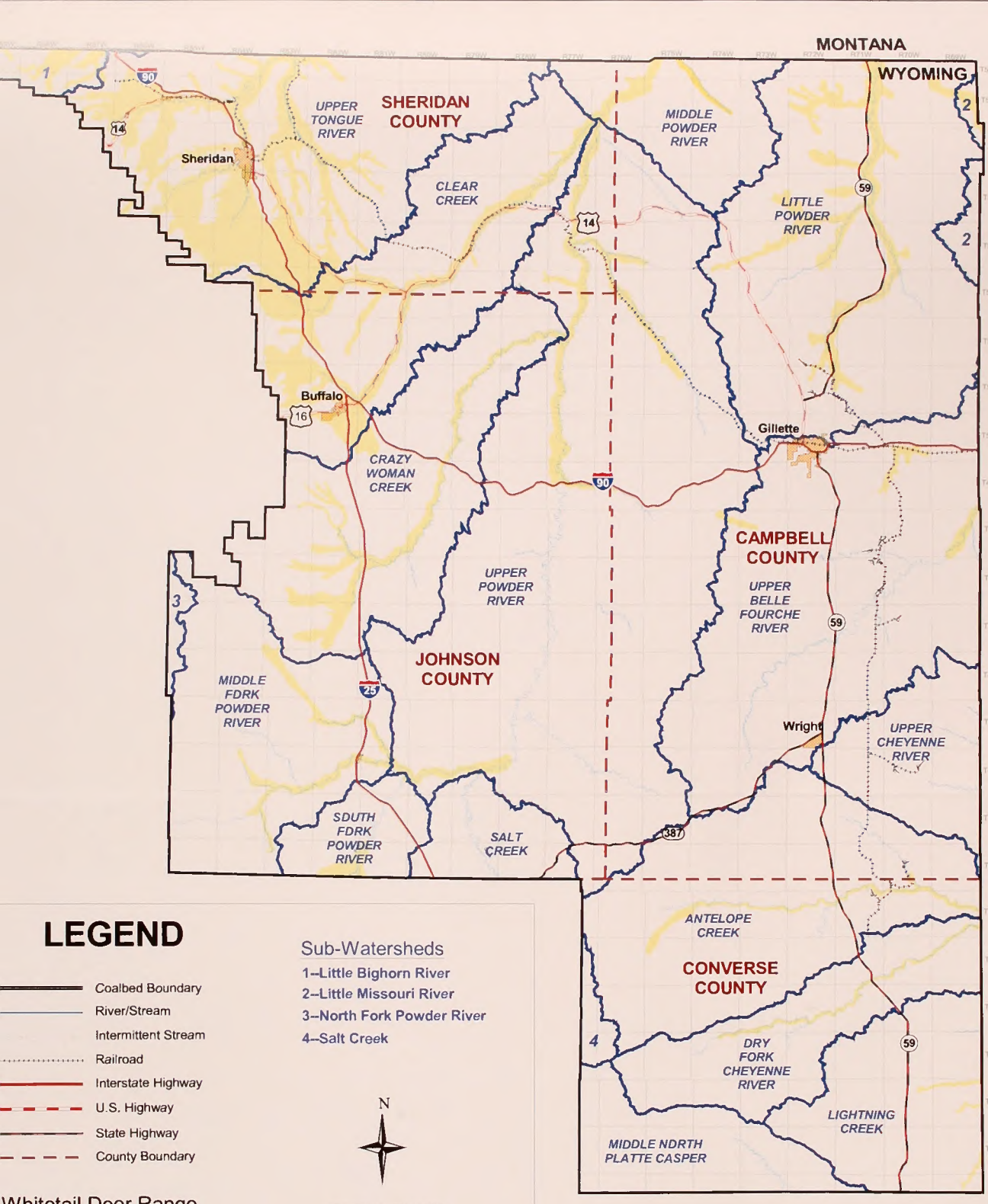
In the Projeet Area, white-tailed deer oceurrenee is restricted to river and stream drainages and riparian habitats associated with the northern foothills of the Bighorn Mountains. They tend to be absent from large expanses of prairie and shrubland. The type and distribution of white-tailed deer ranges within sub-watersheds and by land ownership are presented in Table 3–24 and Table 3–25, respeetively. Figure 3–11 depiets white-tailed deer ranges within the Project Area. The distribution of white-tailed deer ranges by vegetation type is presented in Table 3–26.

Table 3–23 Existing Pronghorn Disturbance by Sub-watershed

	Pronghorn Ranges (acres)					
Sub-watershed	Severe Winter	Winter	Winter Yearlong	Yearlong	Spring, Summer, Fall	Total
Little Bighorn River	0	0	0	0	0	0
Upper Tongue River	0	0	1,407	3,953	0	5,359
Middle Fork Powder River	0	0	270	0	0	270
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	0	1,655	6,523	7,404	0	15,581
South Fork Powder River	0	0	0	260	0	260
Salt Creek	0	0	10	230	0	240
Crazy Woman Creek	0	0	0	1,015	0	1,015
Clear Creek	0	0	0	2,049	0	2,049
Middle Powder River	0	1,000	0	3,240	599	4,839
Little Powder River	0	187	10,785	13,526	0	24,498
Little Missouri River	0	0	70	70	0	140
Antelope Creek	80	0	1,273	9,693	0	11,046
Dry Fork Cheyenne River	60	0	290	760	0	1,110
Upper Cheyenne River	0	0	1,104	1,294	0	2,398
Lightning Creek	0	0	1,140	2,660	0	3,800
Upper Belle Fourche River	0	0	20,799	11,344	0	32,142
Middle North Platte Casper	0	0	50	87	0	137
Total	140	2,841	43,721	57,583	599	104,884

Table 3–24 Distribution of White-tailed Deer Ranges by Sub-watershed

	Ranges (acres)		
Sub-watershed	Winter Yearlong	Yearlong	Total
Little Bighorn River	0	16,475	16,475
Upper Tongue River	0	265,929	265,929
Middle Fork Powder River	0	31,635	31,635
North Fork Powder River	0	0	0
Upper Powder River	0	71,096	71,096
South Fork Powder River	0	9,383	9,383
Salt Creek	0	321	321
Crazy Woman Creek	0	67,473	67,473
Clear Creek	0	130,990	130,990
Middle Powder River	4,671	12,554	17,225
Little Powder River	0	102,407	102,407
Little Missouri River	0	4,681	4,681
Antelope Creek	0	17,986	17,986
Dry Fork Cheyenne River	0	11,681	11,681
Upper Cheyenne River	0	0	0
Lightning Creek	0	4,731	4,731
Upper Belle Fourche River	0	13,633	13,633
Middle North Platte Casper	0	0	0
Total	4,671	760,976	765,647



LEGEND

- Coalbed Boundary
- River/Stream
- Intermittent Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek

N

Scale 1 ; 775,000

Whitetail Deer Range

- Winter Yearlong
- Yearlong

10 0 10 20 30 Miles

10 0 10 20 30 40 Kilometers



Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 3-11
WHITE-TAILED DEER RANGES

ANALYSIS AREA:	Campbell, Converse, Johnson & Sheridan Counties, Wyoming
DATE: 12/26/01	ArcView File: C:\1611_v1\data\maps.apr Layout: Whitetail Deer
	DRAWN BY: MSH

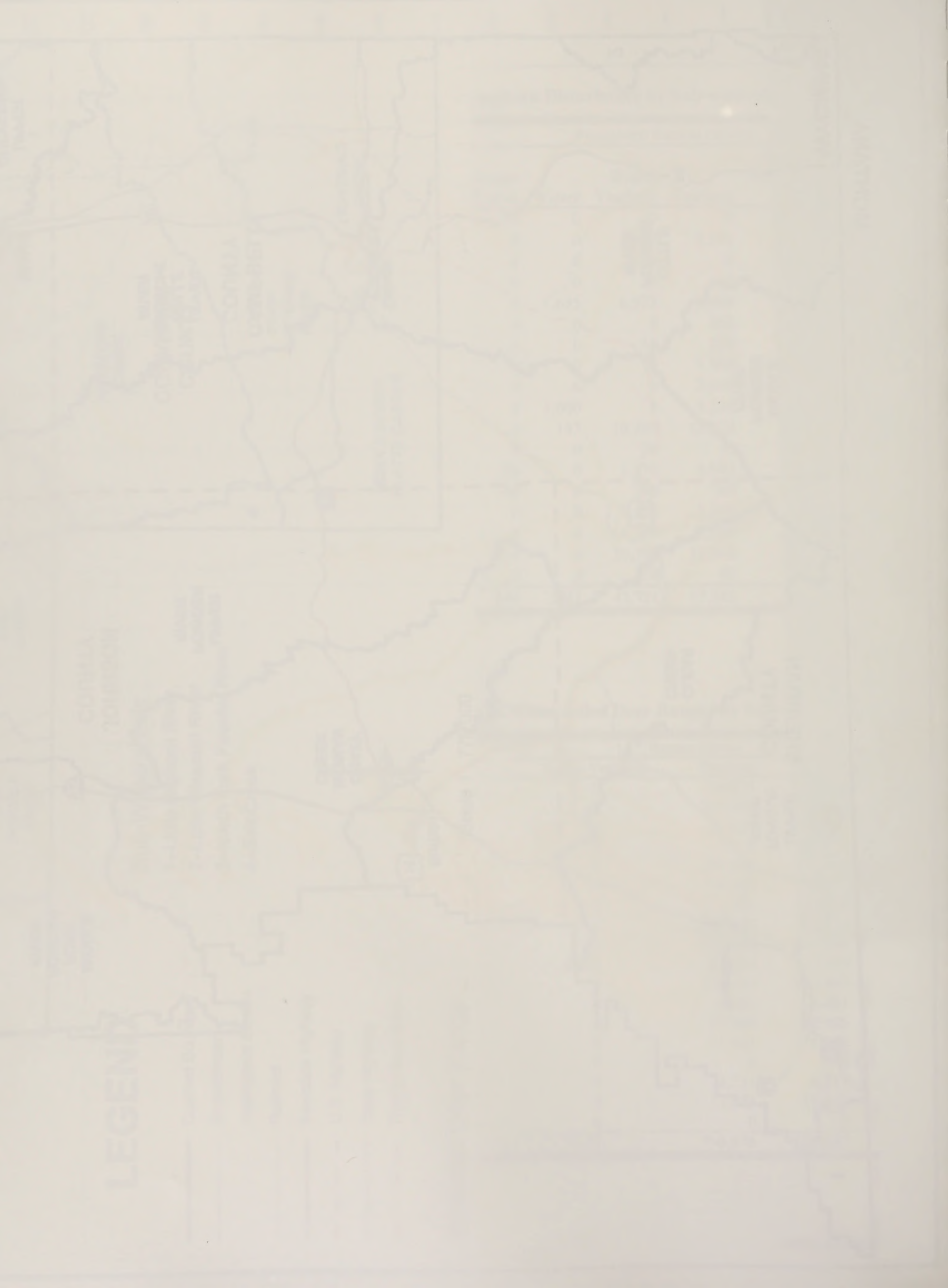


Table 3–25 Distribution of White-tailed Deer Ranges by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Winter Yearlong	259	0	0	515	3,898	4,671
Yearlong	22,410	1,059	5,054	69,220	663,229	760,972
Total	22,669	1,059	5,054	69,735	667,127	765,643

Table 3–26 Distribution of White-tailed Deer Ranges by Vegetation Type

	White-tail Deer Ranges (acres)	
Vegetation Type	Winter Yearlong	Yearlong
Agriculture	0	79,001
Barren	91	10,121
ConiferousForest	473	90,34
ForestedRiparian	0	5,647
HerbaceousRiparian	0	2,281
MixedGrassPrairie	1,818	242,604
OtherShrublands	0	13,730
SagebrushShrublands	382	133,547
ShortgrassPrairie	1,469	161,213
ShrubbyRiparian	11	340,44
Water	0	2,367
WetMeadow	428	67,395

As a result of past human activities in the Project Area, substantial areas of white-tailed deer ranges have been altered from their natural conditions. Human disturbances include, but are not limited to, agriculture, mining, roads, urban areas, oil and gas well pads, compressor sites, and other ancillary facilities. Table 3–27 and Table 3–28 present existing disturbance to white-tailed deer ranges by owner and sub-watershed, respectively.

Table 3–27 Existing White-tailed Deer Disturbance by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Yearlong	69	0	0	1,244	6,741	8,053
Total	69	0	0	1,244	6,741	8,053

Table 3–28 Existing White-tailed Deer Disturbance by Sub-watershed

Sub-watershed	White-tailed Deer Range (acres)	
	Yearlong	Total
Little Bighorn River	0	0
Upper Tongue River	3,065	3,065
Middle Fork Powder River	30	30
North Fork Powder River	0	0
Upper Powder River	1,695	1,695
South Fork Powder River	0	0
Salt Creek	0	0
Crazy Woman Creek	868	868
Clear Creek	1,059	1,059
Middle Powder River	39	39
Little Powder River	853	853
Little Missouri River	0	0
Antelope Creek	50	50
Dry Fork Cheyenne River	30	30
Upper Cheyenne River	0	0
Lightning Creek	30	30
Upper Belle Fourche River	331	331
Middle North Platte Casper	0	0
Total	8,050	8,050

Mule Deer

Mule deer occur throughout western North America from central Mexico to northern Canada. Typical habitats include shortgrass and mixed grass prairies, sagebrush and other shrublands, coniferous forests, and forested and shrubby riparian areas. In Wyoming, mule deer occur in mountains and associated foothills, broken hill country, and prairie grasslands and shrublands (Clark and Stromberg 1987). Browse is an important component of the mule deer's diet throughout the year, comprising as much as 60 percent of total intake during autumn, while forbs and grasses typically make up the rest of their diet (Fitzgerald et al. 1994). This species tends to be more migratory than white-tailed deer, traveling from higher elevations in the summer to winter ranges that provide more food and cover. Fawn mortality is typically due to predation or starvation. Adult mortality often occurs from hunting, winter starvation, and automobile collisions. Typical predators may include coyotes, bobcats, golden eagles, mountain lions, bears, and domestic dogs (Fitzgerald et al. 1994).

WGFD has delineated mule deer into herd units to estimate population. The following herd units reside entirely or partially within the Project area: 319, 320, 321, 322, 752, 753, and 755.

In the Project Area, mule deer ranges occur in nearly all areas, except in several areas located approximately between Wright and Gillette. The type and distribution of mule deer ranges within sub-watersheds and by land ownership are presented Table 3–29 and Table 3–30, respectively. Figure 3–12 depicts mule deer

ranges within the Project Area. The distribution of mule deer ranges by vegetation type is presented in Table 3–31.

Table 3–29 Mule Deer Ranges by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Winter Yearlong	542,496	19,846	73,846	352,432	2,842,439	3,831,058
Yearlong	211,891	74,036	164,125	231,770	2,552,761	3,234,584
Spring, Summer, Fall	25,481	0	0	13,629	88,627	127,738
Total	779,868	93,883	237,970	597,832	5,483,827	7,193,380

Table 3–30 Mule Deer Ranges by Sub-watershed

	Ranges (acres)			
Sub-watershed	Spring, Summer, Fall	Winter Yearlong	Yearlong	Total
Little Bighorn River	1,427	44,368	3,790	49,585
Upper Tongue River	8,091	589,648	135,813	733,552
Middle Fork Powder River	101,252	341,123	22,080	464,455
North Fork Powder River	1,824		18,851	20,675
Upper Powder River	0	950,809	611,233	1,562,042
South Fork Powder River	0	75,344	39,012	114,356
Salt Creek	0	71,512	73,308	144,820
Crazy Woman Creek	13,373	368,633	166,283	548,289
Clear Creek	1,852	466,860	78,159	546,871
Middle Powder River	0	158,916	65,316	224,232
Little Powder River	0	468,758	291,841	760,599
Little Missouri River	0	37,106	1,422	38,528
Antelope Creek	0	68,433	517,320	585,753
Dry Fork Cheyenne River	0	67,233	242,087	309,320
Upper Cheyenne River	0	1,502	142,947	144,449
Lightning Creek	0	49,550	258,775	308,325
Upper Belle Fourche River	0	7,954	425,028	432,982
Middle North Platte Casper	0	64,082	148,493	212,575
Total	127,819	3,831,832	3,241,758	7,201,409

WGFD has estimated the population size of all herd units within the Project Area to be 157,128 (Rothwell 2001). This number excludes data from herd units 754, which was unavailable.

The overall population trend of mule deer in the Project area has increased and stabilized. In general, herd units have reached WGFD population objectives. As

of 2000, the average herd unit population is 15.7 percent above the population objective (Rothwell 2001).

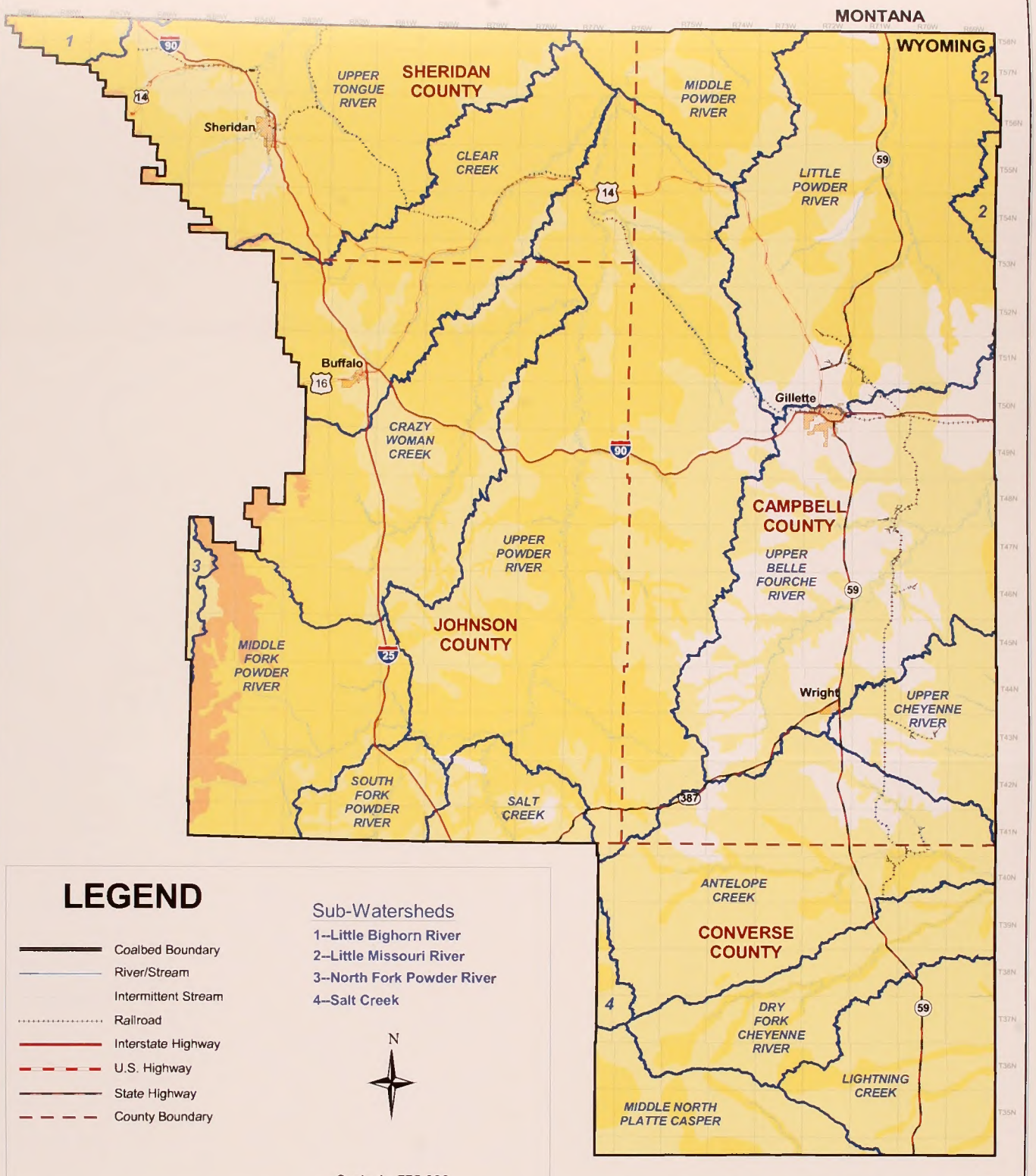
Table 3–31 Distribution of Mule Deer Ranges by Vegetation Type

	Mule Deer Ranges (acres)		
Vegetation Type	Winter Yearlong	Yearlong	Spring, Summer, Fall
Agriculture	74,475	37,727	0
Aspen	3	0	68
Barren	59,803	44,277	632
Coniferous Forest	118,778	41,538	31,044
Forested Riparian	7,910	3,159	394
Herbaceous Riparian	10,191	2,079	67
Mixed Grass Prairie	911,071	526,683	39,527
Other Shrublands	128,796	36,680	12,407
Sagebrush Shrublands	872,263	1,033,811	33,402
Short-grass Prairie	1,469,575	1,473,443	7,766
Shrubby Riparian	48,794	7,178	1,502
Urban/Disturbed	1,744	2,618	0
Water	4,662	3,872	87
Wet Meadow	124,575	27,909	923

Because of past human activities in the Project Area, substantial areas of mule deer ranges have been altered from their natural conditions. Human disturbances include, but are not limited to, agriculture, mining, roads, urban areas, oil and gas well pads, compressor sites, and other ancillary facilities. Table 3–32 and Table 3–33 present existing disturbances to pronghorn ranges by owner and sub-watershed, respectively.

Table 3–32 Existing Mule Deer Disturbance by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Winter Yearlong	1,183	90	280	3,590	20,649	25,792
Yearlong	1,007	275	1,050	5,624	44,116	52,073
Total	2,190	365	1,330	9,215	64,765	77,864



LEGEND

- Coalbed Boundary
- River/Stream
- Intermittent Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek

N

Scale 1 : 775,000

10 0 10 20 30 Miles

10 0 10 20 30 40 Kilometers

Mule Deer Range

- Spring, Summer, Fall
- Winter Yearlong
- Yearlong



Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 3-12
MULE DEER RANGES

ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_v1\data\maps.apr Layout: Mule Deer
	DRAWN BY: MSH

Table 3–33 Existing Mule Deer Disturbance by Sub-watershed

Sub-watershed	Mule Deer Range (acres)		
	Winter Yearlong	Yearlong	Total
Little Bighorn River	0	0	0
Upper Tongue River	5,460	27	5,487
Middle Fork Powder River	270	0	270
North Fork Powder River	0	0	0
Upper Powder River	10,008	7,289	17,297
South Fork Powder River	240	20	260
Salt Creek	100	200	300
Crazy Woman Creek	81	934	1,015
Clear Creek	1,104	1,026	2,130
Middle Powder River	3,604	1,369	4,973
Little Powder River	3,390	16,593	19,984
Little Missouri River	165	0	165
Antelope Creek	215	5,655	5,870
Dry Fork Cheyenne River	320	790	1,110
Upper Cheyenne River	0	1,437	1,437
Lightning Creek	840	2,960	3,800
Upper Belle Fourche River	0	13,551	13,551
Middle North Platte Casper	10	127	137
Total	25,807	51,978	77,786

Elk

Elk formerly ranged over much of central and western North America from the southern Canadian Provinces and Alaska south to the southern United States, and eastward into the deciduous forests. In Wyoming, this species occurs throughout the state occupying a variety of habitats including coniferous forests, mountain meadows, short- and mixed-grass prairies and, sagebrush and other shrublands. Similar to other members of the deer family, this species relies on a combination of browse, grasses and forbs depending on their availability throughout the seasons. Elk tend to be migratory, moving between summer and winter ranges. Typically, mortality is often due to predation on calves, hunting, and winter starvation. Predators may include coyotes, mountain lions, bobcats, bears, and golden eagles.

WGFD has estimated the population size of all herd units within the Project Area to be 11,787 (Rothwell 2001).

The overall population trend of elk in the Project Area has increased and stabilized. In general, herd units have reached WGFD population objectives. As of 2000, the average herd unit population is 74.4 percent above the population objective (Rothwell 2001).

In the Project Area, elk ranges are concentrated in the Bighorn Mountains and asoociated foothills, the Fortification Creek Area that is west of Gillette, and north of I-90 in the center of the Project Area, Medicine Bow Mountains in the

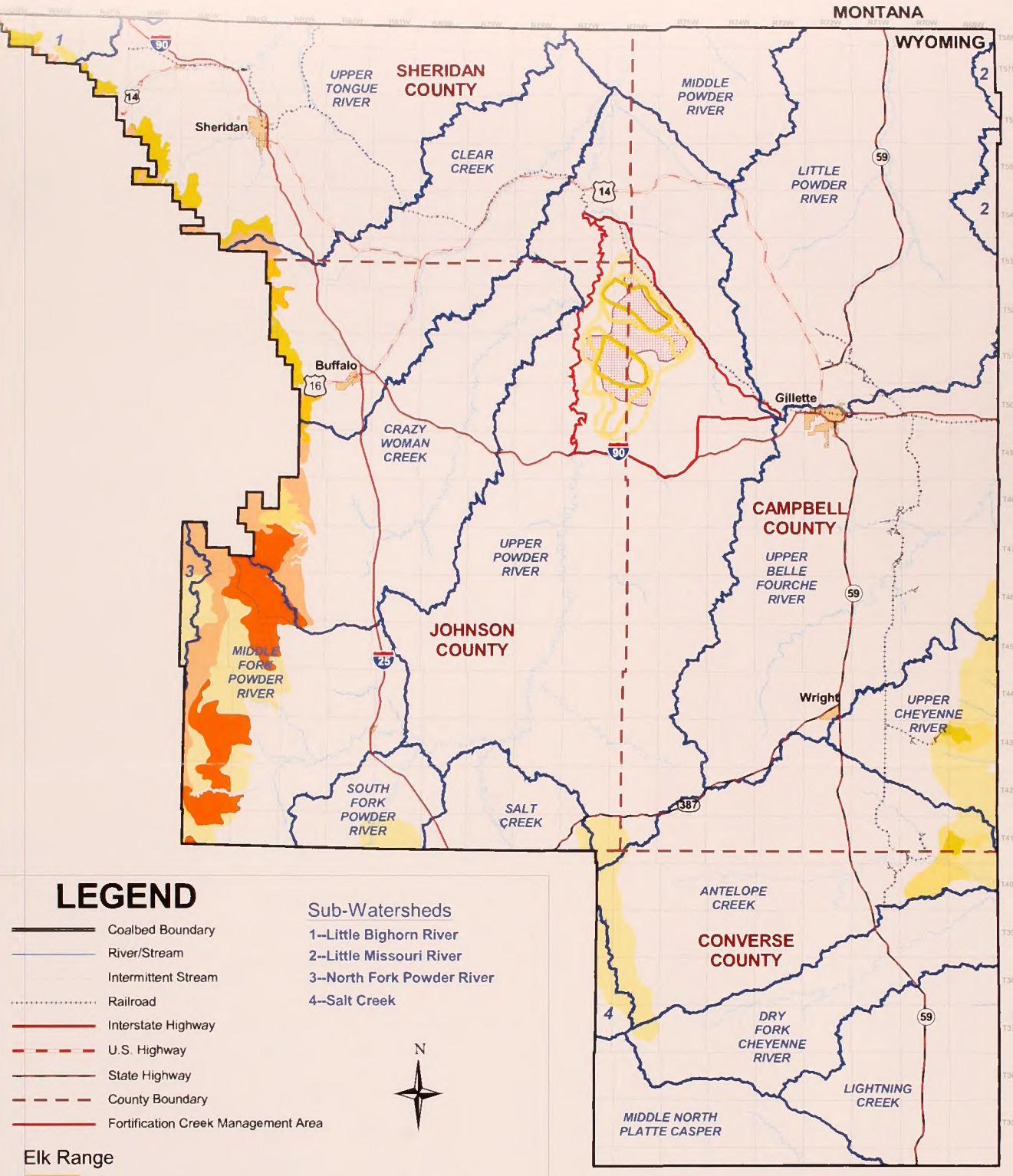
south, and Black Hills in the southeast. The type and distribution of elk ranges within sub-watersheds and by land ownership are presented in Table 3–34 and Table 3–35, respectively. Figure 3–13 depicts elk ranges within the Project Area. The distribution of elk ranges by vegetation type is presented in Table 3–36.

Table 3–34 Distribution of Elk Ranges (excluding Fortification Creek) by Surface Ownership

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Crucial Winter	923	0	4,592	5,937	36,979	48,431
Crucial Winter Yearlong	40,783	0	0	11,944	52,200	104,927
Spring, Summer, Fall	17,646	0	0	11,670	75,994	105,310
Winter	140	0	0	2,929	8,755	11,824
Winter Yearlong	3,388	0	21,438	3,660	16,756	45,242
Yearlong	45,744	18,063	38,966	22,777	168,938	294,489
Total	108,624	18,063	64,996	58,917	359,622	610,223

Table 3–35 Elk Ranges (excluding Fortification Creek) by Sub-watershed

	Elk Range (acres)						
Sub-watershed	Crucial Winter	Crucial Winter Yearlong	Spring, Summer, Fall	Winter	Winter Yearlong	Yearlong	Total
Little Bighorn River	4,734	266	1,752	33	2,563	0	9,347
Upper Tongue River	26,992	0	10,266	842	10	0	38,110
Middle Fork Powder River	0	88,623	43,725	0	745	85,917	219,011
North Fork Powder River	0	0	8,490	0	0	12,185	20,675
Upper Powder River	0	0	0	0	0	15,346	15,346
South Fork Powder River	0	0	0	0	0	16,929	16,929
Salt Creek	0	0	0	0	0	19,303	19,303
Crazy Woman Creek	0	16,039	34,760	1,616	10,170	0	62,586
Clear Creek	9,980	0	6,416	9,350	0	0	25,745
Middle Powder River	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0
Antelope Creek	3,401	0	0	0	21,472	61,189	86,062
Dry Fork Cheyenne River	0	0	0	0	597	4,339	4,936
Upper Cheyenne River	3,390	0	0	0	9,700	68,814	81,904
Lightning Creek	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0	10,466	10,466
Middle North Platte Casper	0	0	0	0	0	0	0
Total	48,497	104,928	105,409	11,841	45,257	294,488	610,420



LEGEND

- Coalbed Boundary
- River/Stream
- Intermittent Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary
- Fortification Creek Management Area

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek

N

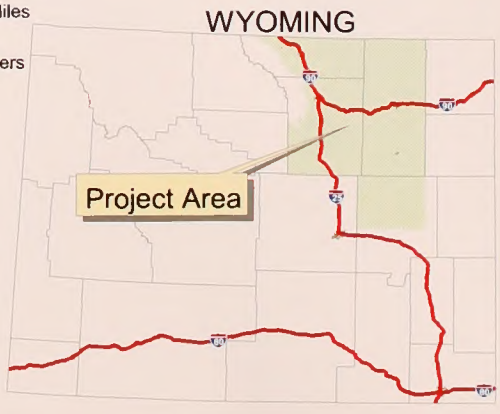
Elk Range

- Critical Winter
- Crucial Winter Yearlong
- Spring, Summer, Fall
- Winter
- Winter Yearlong
- Yearlong
- Parturition

Scale 1 : 775,000

10 0 10 20 30 Miles

10 0 10 20 30 40 Kilometers



Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

POWDER RIVER BASIN OIL/GAS EIS PROJECT	
FIGURE 3-13 ELK RANGES	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_vt\data\maps.apr Layout--Elk
	DRAWN BY: MSH

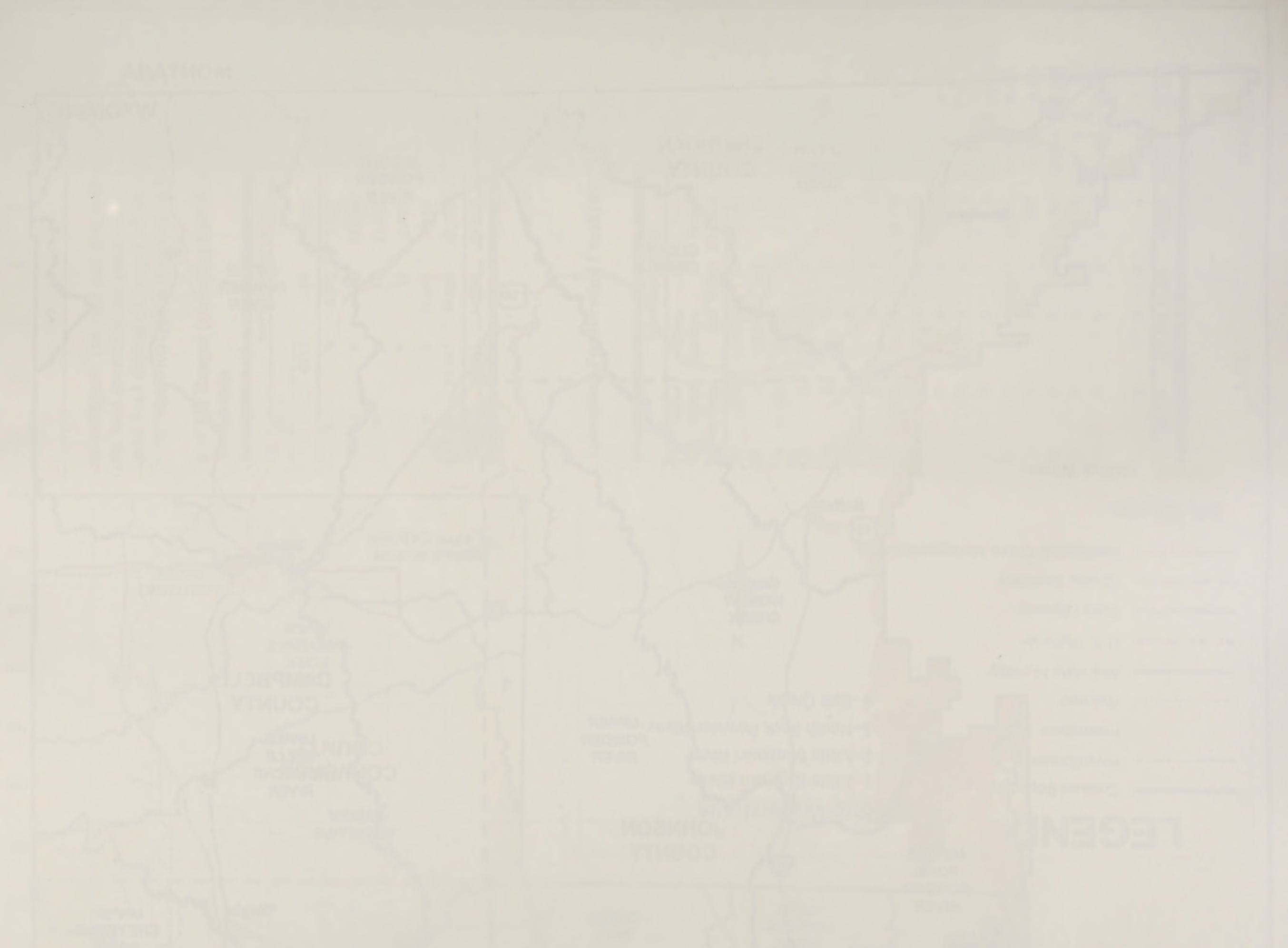


Table 3–36 Distribution of Elk Ranges by Vegetation Type

	Elk Ranges (acres)						
Vegetation Type	Crucial Winter Yearlong	Crucial Winter	Winter	Winter Yearlong	Year long	Spring, Summer, Fall	Unde-termined
Agriculture	0	795	22	0	0	6	6,218
Aspen	0	1	0	2	0	68	0
Barren	1,104	8	0	762	4,092	63	175
Coniferous Forest	23,674	7,698	3,905	6,004	36,823	43,185	29
Forested Riparian	60	1,385	202	460	772	2,892	1,333
Herbaceous Riparian	11	47	25	12	70	49	4,220
Mixed-grass Prairie	33,228	14,918	3,990	6,090	42,884	24,286	37,382
Other Shrublands	16,230	273	111	9	23,507	4,590	21,478
Sagebrush Shrublands	18,396	8,947	2,469	10,784	69,706	24,079	121,606
Short-grass Prairie	11,839	4,378	166	19,672	113,328	1,507	6,970
Shrubby Riparian	347	7,472	690	1,091	133	3,125	0
Water	0	108	25	56	219	87	0
Wet Meadow	40	2,466	237	315	2,955	1,472	0

Because of past human activities in the Project Area, some areas of elk ranges have been altered from their natural conditions. Human disturbances include, but are not limited to, agriculture, mining, roads, urban areas, oil and gas well pads, compressor sites, and other ancillary facilities. Table 3–37 and Table 3–38 present existing disturbances to elk ranges by owner and sub-watershed, respectively.

Table 3–37 Existing Elk Disturbance (excluding Fortification Creek) by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Yearlong	200	0	200	50	250	700
Crucial Winter Yearlong	0	0	0	0	0	0
Crucial Winter	0	0	100	0	0	100
Winter Yearlong	0	0	150	20	50	220
Total	200	0	450	70	30	1,020

Table 3–39 and Table 3–40 present the distribution of Fortification Creek elk ranges by surface owner and sub-watershed, respectively. Table 3–41 and Table 3–42 present existing disturbance to elk ranges in Fortification Creek by surface owner and sub-watershed.

Table 3–38 Existing Elk Disturbance (excluding Fortification Creek) by Sub-watershed

Sub-watershed	Yearlong	Crucial Winter Yearlong	Crucial Winter	Winter Year-long	Total
Little Bighorn River	0	0	0	0	0
Upper Tongue River	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0
North Fork Powder River	0	0	0	0	0
Upper Powder River	60	0	0	0	60
South Frk Powder River	260	0	0	0	260
Salt Creek	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0
Clear Creek	0	0	0	0	0
Middle Powder River	0	0	0	0	0
Little Powder River	0	0	0	0	0
Little Missouri River	0	0	0	0	0
Antelope Creek	190	0	100	210	500
Dry Fork Cheyenne River	0	0	0	0	0
Upper Cheyenne River	190	0	0	10	200
Lightning Creek	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0
Middle North Casper River	0	0	0	0	0
Total	700	0	100	220	1,020

Table 3–39 Elk Ranges (Fortification Creek only) by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Critical Winter	15,772	0	0	2,242	20,219	38,234
PAR	27,857	0	0	3,330	28,105	59,292
Winter Yearlong	33,235	0	0	4,504	33,415	71,155
Yearlong	54,265	0	0	7,689	60,977	122,931

Table 3–40 Elk Ranges (Fortification Creek only) by Sub-watershed

	Ranges (acres)			
Sub-watershed	Critical Winter	PAR	Winter Yearlong	Yearlong
Little Bighorn River	0	0	0	0
Upper Tongue River	0	0	0	0
Middle Fork Powder River	0	0	0	0
North Fork Powder River	0	0	0	0
Upper Powder River	38,234	59,292	71,155	122,931
South Fork Powder River	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	0	0	0	0
Clear Creek	0	0	0	0
Middle Powder River	0	0	0	0
Little Powder River	0	0	0	0
Little Missouri River	0	0	0	0
Antelope Creek	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0
Upper Cheyenne River	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche River	0	0	0	0
Middle North Casper River	0	0	0	0
Total	38,234	59,292	71,155	122,931

Note: Range acreages overlap with each other. Thus, it is not appropriate to sum across categories.

Table 3–41 Existing Elk Disturbance (Fortification Creek) by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Yearlong	0	0	0	0	10	10
Crucial Winter Yearlong	10	0	0	0	19	29
Crucial Winter	44	0	0	26	75	144
Winter Yearlong	68	0	0	58	419	546
Total	122	0	0	84	523	728

Moose

In North America, moose occur from Alaska to the northeastern United States and south along the Rocky Mountains into Colorado. In Wyoming, this species occurs in the western half and isolated southern areas of the state. Typical moose habitats in the Rocky Mountains include willow, spruce, fir, aspen, or birch.

These habitats are common to forested riparian, shrubby riparian, and wet meadow vegetation types. Willow is an important dietary component on all seasonal ranges, especially winter range when grasses, forbs, and aquatic vegetation are less available. Moose tend to have strong affinity for specific home ranges, but will make seasonal migrations in search of suitable forage and habitat. Major mortality factors include hunting, starvation, and predation. Common predators include mountain lion, wolverine, coyote, bear, lynx, and domestic dog (Fitzgerald et al. 1994).

Table 3–42 Existing Elk Disturbance (Fortification Creek) by Sub-watershed

Sub-watershed	Yearlong	Crucial Winter Yearlong	Crucial Winter	Winter Yearlong	Total
Little Bighorn River	0	0	0	0	0
Upper Tongue River	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0
North Fork Powder River	0	0	0	0	0
Upper Powder River	546	29	10	142	727
South Frk Powder River	0	0	0	0	0
Salt Creek	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0
Clear Creek	0	0	0	0	0
Middle Powder River	0	0	0	0	0
Little Powder River	0	0	0	0	0
Little Missouri River	0	0	0	0	0
Antelope Creek	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0
Lightning Creek	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0
Middle North Casper River	0	0	0	0	0
Total	546	29	10	142	727

Moose ranges are extremely limited within the Project Area. In the Project Area ,moose ranges are restricted to areas along the western project boundary in the Bighorn Mountains. In the Rocky Mountains, moose typically rely upon a mixture of willow, spruce, fir, aspen, or birch. The type and distribution of moose ranges within sub-watersheds and by land ownership are presented in Table 3–43 and Table 3–44, respectively. Figure 3–14 depicts moose ranges within the Project Area. The distribution of moose ranges by vegetation type is presented in Table 3–45.

No existing disturbance for moose habitats occurs within the Project Area.

Table 3–43 Distribution of Moose Ranges by Surface Ownership

	Surface Owner (acres)				
	BLM				
Range	BFO	CFO	FS	State	Private
Crucial Winter Yearlong	9	0	0	100	832
Crucial Yearlong	0	0	1	0	138
Undetermined/Undocumented	0	0	0	7	609
Winter Yearlong	0	0	0	169	1,634
Yearlong	0	0	1	285	2,772
Total	9	0	2	561	5,985

Table 3–44 Distribution of Moose Ranges by Sub-watershed

	Moose Ranges (acres)				
Sub-watershed	Crucial Winter Yearlong	Crucial Yearlong	Undetermined/ Undocumented	Winter Yearlong	Yearlong
Little Bighorn River	0	0	0	0	420
Upper Tongue River	940	139	0	1,473	2,161
Middle Fork Powder River	0	0	9	0	0
North Fork Powder River	0	0	654	0	0
Upper Powder River	0	0	0	0	0
South Fork Powder River	0	0	0	0	0
Salt Creek	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	443
Clear Creek	0	0	0	330	181
Middle Powder River	0	0	0	0	0
Little Powder River	0	0	0	0	0
Little Missouri River	0	0	0	0	0
Antelope Creek	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0
Lightning Creek	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0
Middle North Casper River	0	0	0	0	0
Total	940	139	663	1,803	3,205

Table 3–45 Moose Ranges by Vegetation Type

	Moose Ranges (acres)				
Vegetation Type	Crucial Yearlong	Crucial Winter Yearlong	Winter Yearlong	Yearlong	Undetermined
Agriculture	0	120	670	499	0
Aspen	10	1	0	53	0
Coniferous Forest	843	1,371	2,800	10,976	1,792
Forested Riparian	41	965	798	947	1,628
Herbaceous Riparian	5	0	3	43	0
Mixed Grass Prairie	239	2,772	7,261	9,231	341
Other Shrublands	0	0	0	244	8
Sagebrush Shrublands	252	841	2,436	4,121	3,117
Shortgrass Prairie	0	47	111	222	33
Shrubby Riparian	8	3,151	3,666	6,128	0
Water	0	0	38	0	0
Wet Meadow	96	854	1,755	2,037	214

Raptors

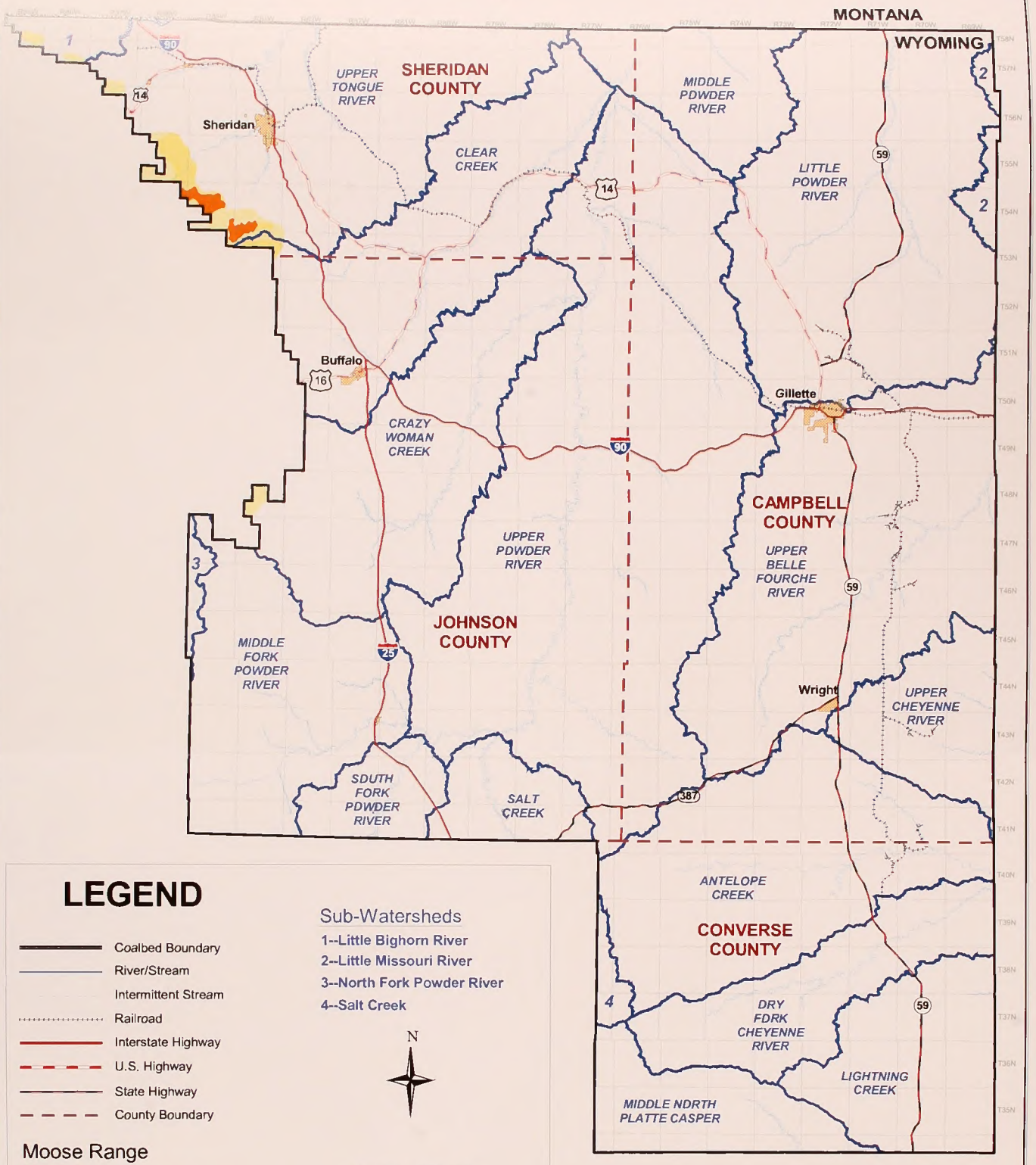
Common raptor species expected to occur in suitable habitats within the Project Area include northern harrier (*Circus cyaneus*), golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), ferruginous hawk (*Buteo regalis*), American kestrel (*Falco sparverius*), prairie falcon (*Falco mexicanus*), great horned owl (*Bubo virginianus*), short-eared owl (*Asio flammeus*), and burrowing owl (*Athene cunicularia*). The following sections briefly describe distribution, occurrence in Wyoming, ecology, and potential threats to raptor species that may occur within the Project Area.

Northern Harrier

This species occurs throughout much of North America with highest densities in the prairie pothole region of the U.S. and Canada (Kingery 1998). Harriers nest in a variety of habitats, including native and non-native grasslands, agricultural lands, and emergent wetland marshes and mountain sagebrush (Kingery 1998). In Wyoming, this species is a common summer resident feeding mostly on small mammals that it discovers while gliding (Luce et al. 1999). Possible threats may include direct disturbance or destruction of breeding habitats, habitats important to prey species, and indirect disturbance from construction, operation, or reclamation activities that may lead to nest failure or abandonment.

Bald Eagle

The bald eagle occurs throughout North America from Alaska to Newfoundland, and from southern Florida to southern California. In Wyoming, this bird is a breeding resident occurring in suitable habitats throughout the state. Breeding pairs utilize large, mature cottonwoods or conifer trees to hold their nests. These trees are often located near large streams, rivers, or lakes that support large populations of fish, an important prey base. Eagles also rely upon medium-sized



LEGEND

- Coalbed Boundary
- River/Stream
- Intermittent Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek

Moose Range

- Crucial Winter Yearlong
- Crucial Yearlong
- Winter Yearlong
- Year Long

N

Scale 1 : 775,000

10 0 10 20 30 Miles

10 0 10 20 30 40 Kilometers



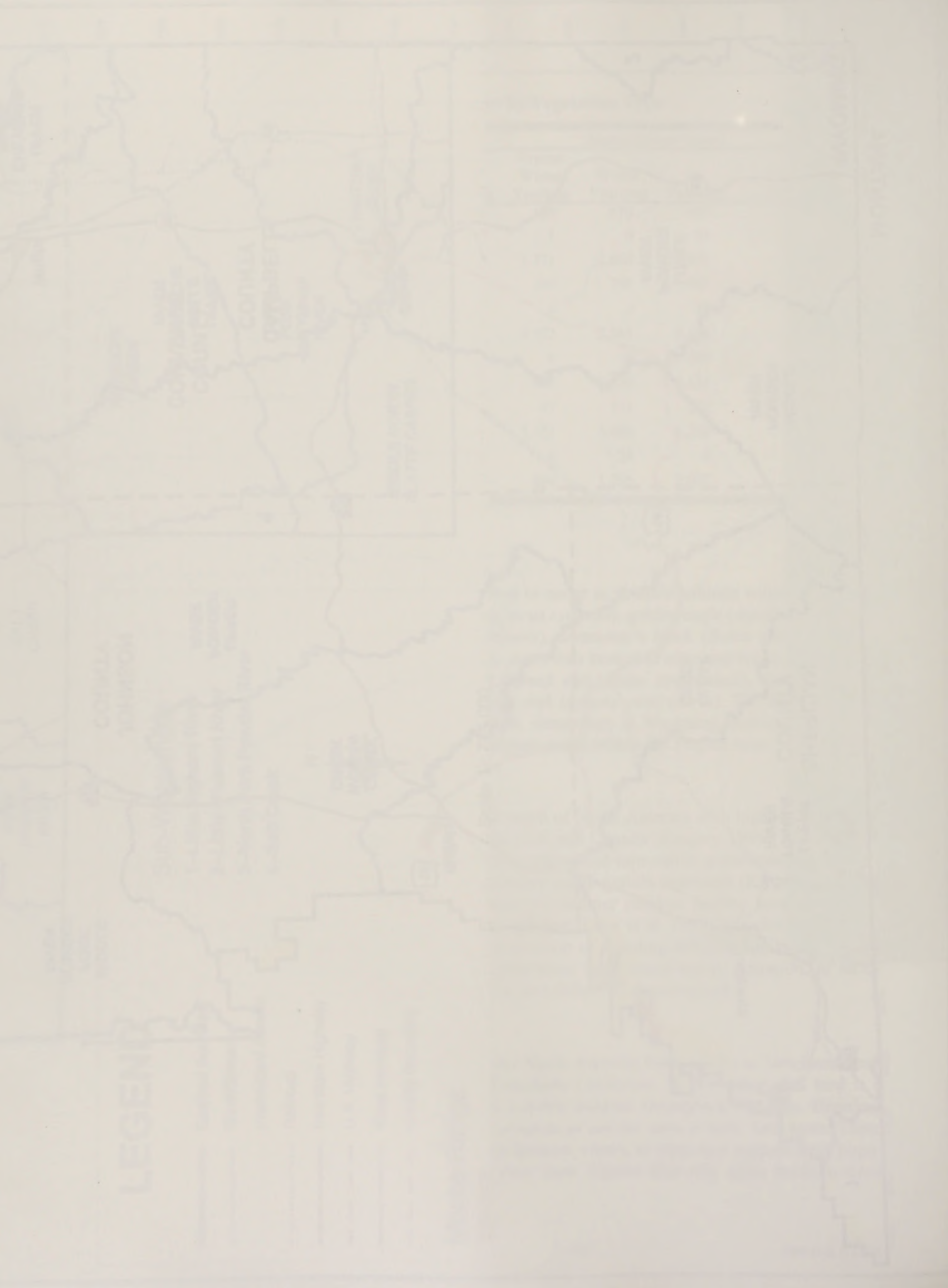
Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 3-14
MOOSE RANGES

ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_v1\data\maps.apr Layout--Moose
	DRAWN BY: MSH



mammals (e.g., prairie dogs and jackrabbits), waterfowl, and wildlife and livestock carrion, depending upon the season and availability. Bald eagles nest throughout Wyoming and the Project Area. Nest location data for nests within the Project Area was provided by the WGFD Nongame Division. In the Project Area, active nests and winter roosts tend to be associated with forested riparian areas and large lakes and reservoirs that have mature cottonwood trees for nesting and roosting. Threats to this species include human disturbance, loss of suitable nesting and roosting trees, and prey scarcity due to anthropogenic effects.

Golden Eagle

In North America, this species occurs throughout the mountain and grassland regions where medium-sized mammals are available and abundant (Glinski 1998). Golden eagles typically nest on open cliffs or in trees. Important foraging habitats include grasslands, sagebrush, and farmlands (Kingery 1998). In Wyoming, this species is considered a common year-round resident feeding mostly on jackrabbits, rodents, small mammals, and carrion in the winter (Luce et al. 1999). Possible threats to this species may include disturbance of nesting areas leading to abandonment and disturbance or destruction of important habitats to prey species.

Red-tailed Hawk

Red-tailed hawks use a variety of habitats and range from Alaska south to Panama and east to Nova Scotia and the Virgin Islands (Kingery 1998). This species typically nest in patches of tall trees or on secluded cliff faces. In Wyoming, this species is considered year-round resident common to most habitats under 9,000 feet elevation including prairie grasslands, riparian areas, sagebrush communities, and pinyon/juniper woodlands (Luce et al. 1999). Typical prey include rodents and other small mammals. Possible threats to this species may include direct disturbance or destruction of breeding habitats, habitats important to prey species, and indirect disturbance from construction, operation, or reclamation activities that may lead to nest abandonment.

Swainson's Hawk

The Swainson's hawk is a New World hawk, breeding in North America and wintering in South America. This species will build their own nest in the tops of isolated trees or use nests built by magpies, crows, ravens, or other hawks (Kingery 1998). In Wyoming, this species is considered a summer resident common to grasslands and shrublands under 9,000 feet elevation (Luce et al. 1999). This species typically preys on rodents, small mammals, and occasionally rabbits. Concern for this species has increased following reports of significant habitat loss and exposure to pesticides on wintering grounds in South America. Swainson's hawk are relatively sensitive to human disturbance near active nests. Possible threats to this species may include direct disturbance or destruction of breeding habitats, habitats important to prey species, and indirect disturbance from construction, operation, or reclamation activities that may lead to nest abandonment.

Rough-legged Hawk

The rough-legged hawk (*Buteo lagopus*) occurs from the northern latitudes of Canada during the summer months and in the United States from California east to Maine in the winter months. In Wyoming, this species occurs in the short- and mixed-grass prairies and sagebrush and other shrublands. Winter prey species include rodents, medium-sized mammals and upland birds. This species is considered a common winter resident in Wyoming (Luce et al. 1999). The primary threats in the Project Area are the loss of suitable prey and disturbance of suitable wintering and hunting habitats.

Ferruginous Hawk

The ferruginous hawk (*Buteo regalis*) occurs from southwestern Canada through the western U.S. and south into northern Mexico. This species breeds mainly in the northern part of its range and occupies the southern parts only in the winter. The heart of the most suitable nesting habitat is in the Dakotas (Glinski 1998). Nesting habitat is typically in shortgrass prairies where trees, similar constructed structures, cliffs, or even hilltops are used. Preferred foraging habitats include grasslands and shrublands (Kingery 1998). Ferruginous hawks typically feed on small to medium-sized mammals including jackrabbits, cottontails, ground squirrels, and prairie dogs (Kingery 1998). In Wyoming, this species is considered a common year-round resident (Luce et al. 1999). Possible threats include physical disturbance to suitable nesting habitats and habitats vital to populations of prey species.

American Kestrel

The American kestrel (*Falco sparverius*) is found throughout North and South America from Alaska south to the southernmost tip of South America. This species is known to breed in every state of the U.S., except Hawaii, and each province of Canada. American kestrels prefer open country with sufficient perches (e.g., dead trees, rock outcrops, utility poles and wires) for hunting insects and small mammals (Kingery 1998). Nesting sites often include tree cavities, crevices, cliffs, and nest boxes. In Wyoming, the kestrel is a common summer resident of suitable habitats below 8,500 feet elevation. Relatively tolerant of human activity, a possible threat to this species would be removal or destruction of suitable nesting substrates.

Prairie Falcon

The prairie falcon (*Falco mexicanus*) range over the western half of North America from southern Alberta, Saskatchewan, and British Columbia south to central Mexico (Kingery 1998). This species tends to nest on open cliff faces. Prairie falcons hunt birds and small mammals from perches and while soaring. In Wyoming, the prairie falcon is considered a common resident nesting in cliff habitats of open areas (Luce et al. 1999). Threats to this species may include displacement from traditionally nesting habitats due to human activity.

Great Horned Owl

The great horned owl (*Bubo virginianus*) occurs from the northern edge of the boreal forest in Alaska and Canada to the southern tip of South America. This owl typically nests in wooded areas adjacent to open spaces such as shrublands,

grasslands, and farm fields that provide excellent opportunity for hunting rodents and other small mammals (Kingery 1998). In Wyoming, this owl is considered a common resident of most habitats under 9,000 feet elevation, especially cottonwood and riparian areas (Luce et al. 1999). Habitat loss is an important consideration in some areas of this species range, but in Wyoming human-caused mortalities is likely a more serious issue.

Short-eared Owl

The short-eared owl (*Asio flammeus*) occurs throughout Canada and central and northern United States. In Wyoming, this species is a common year-resident (Luce et al. 1999). This owl is a ground-nesting species, building its nest of grasses, weeds, and down feathers in short- and mixed-grass prairies and herbaceous wetlands (Kingery 1998). Threats to this species include the conversion or alternation of historically treeless prairies and increased predation by domestic dogs and cats, foxes, coyotes, and skunks due the expansion of human development.

Burrowing Owl

The burrowing owl (*Athene cunicularia*) occurs throughout the western United States, southwestern Canada, and northern Mexico. In Wyoming, this species is a breeding summer resident occurring throughout much of the state and (Luce et al. 1999). This species occupies rodent burrows and nests primarily in short- and mixed-grass prairies and shrublands. In many areas, this owl favors prairie dog colonies, that provide well-maintained burrows for nesting, mounds for perching, and low vegetation for unobstructed views of potential predators. Threats to rural populations include plague outbreaks, poisoning of rodent colonies, and elimination of nesting sites due to the conversion of prairie and shrublands to agricultural uses (Kingery 1998).

The Project Area is known to support suitable habitat for each of the raptor species listed (Luce et al. 1999). Although the presence of these raptor species has been documented in the Project Area, more specific data regarding their population size or patterns of occurrence were not available.

Upland Game Birds

Several species of upland game birds may occur within the Project Area, including ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*), blue grouse (*Dendragapus obscurus*), wild turkey (*Meleagris gallopavo*), mourning dove (*Zenaida macroura*), sage grouse (*Centrocercus urophasianus*) and sharp-tailed grouse (*Tympanuchus phasianellus*) (Luce et al. 1999). Specific concerns regarding the sage grouse and sharp-tailed grouse were identified during the scoping process. No other species were spcifically identified during the scoping process and therefore are not addresed further.

Sage Grouse

The sage grouse is a species of the sagebrush community in the plains and foothills of the arid west. This species occupies short- and mixed-grass prairies, sagebrush shrublands and other shrubland communities, wet meadows, and agricultural areas (Luce et al. 1999). Males of this species have an extravagant mat-

ing display that is performed on historical strutting areas termed "leks" (Terres 1980). In Wyoming, this species occurs as a breeding resident of habitats below 8,300 feet elevation throughout the state (Luce et al. 1999). Sage grouse leks occur throughout the Project Area. Direct disturbance of leks, nesting areas, and brood-rearing areas, and other human disturbance are the key threats to this species in the Project Area.

The 2001 Sage Grouse Job Completion Report, Sheridan Region, was referred to for information specific to the Project Area (Oedekoven 2001). The Sheridan Region of the WGFD approximates the Project Area. In the Sheridan Region, 269 lek locations are documented. Although distributed widely throughout the Project Area, most of these known leks occur in Campbell County on privately owned lands. Lek complexes are defined as one or more leks within approximately 0.5 to 2.0 miles of each other. Male sage grouse are known to breed on several different leks within a single breeding season. The WGFD rely upon lek complex data as the basis for analyzing sage grouse population trends. The number of active lek complexes has remained relatively stable for the past ten years, primarily because a single lek within a complex will characterize that complex as active. Average peak male attendance in 2001 was significantly lower than the previous year. Based on typical sex ratios of approximately one male for every two females, the trend in sage grouse populations in the Sheridan Region are experiencing a low period during a ten-year cycle of highs and lows. Overall, the sage grouse population appears to be steadily declining within the Project Area.

Plains Sharp-tailed Grouse

The sharp-tailed grouse occurs throughout much of central Canada and from Montana to central Nebraska. This species inhabits short- and mixed-grass prairie, sagebrush shrublands, woodland edges, and river canyons. In Wyoming, this species is restricted to mixed-grass prairie grasslands, sagebrush, shrublands, shrubby riparian areas and wet meadows of the eastern half of the state (Luce et al. 1999). Each spring, the males perform elaborate mating dances on historical dancing grounds called leks (Terres 1980). This species is a common breeding resident throughout Wyoming and is expected to occur in suitable habitats within the Project Area (Luce et al. 1999). Data provided by the WGFD, Nongame Division, indicate plains sharp-tailed grouse leks occur primarily in the northwestern portion of the Project Area. Physical disturbance of nesting and brood-rearing habitats and human disturbance at or near leks are primary threats to this species within the Project Area.

Waterfowl

Suitable waterfowl habitats within the Project Area include major rivers, streams, creeks, draws, lakes, and ponds. Waterfowl species that can be expected to occur in the area include Canada goose (*Branta canadensis*), wood duck (*Aix sponsa*), mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), green-winged teal (*Anas crecca*), American wigeon (*Anas americana*), northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), blue-winged teal (*Anas discors*), cinnamon teal (*Anas cyanoptera*), canvasback (*Aythya valisineria*), and redhead (*Aythya americana*) (National Geographic 1999).

The occurrence and distribution of these species is variable and influenced by local conditions such as aquatic habitat, adjacent upland habitat, season, and land use practices. These waterfowl species are expected to occur in suitable habitats within the Project Area during the appropriate species-specific nesting, migration, and wintering seasons.

Aquatic Species

Of the 18 sub-watersheds identified within the Project Area, ten would receive produced water from CBM wells. These ten sub-watersheds are included in the five major watersheds within the project area. The five major watersheds and their corresponding sub-watersheds are:

- Powder River Basin, including five sub-watersheds: Upper Powder River Basin, Salt Creek Basin, Crazy Woman Creek Basin, Clear Creek Basin, and the Middle Powder River Basin;
- Little Powder River Basin;
- Upper Tongue River Basin;
- Upper Belle Fourche River Basin;
- Upper Cheyenne River Basin including two sub-watersheds: Antelope Creek Basin and Upper Cheyenne River Basin.

Additional details about the sub-watersheds are presented in the discussion of surface water, which begins on page 3–14.

Specific habitat data for many of the streams and rivers within the Project Area were not available; however, general existing conditions for the five major watersheds were available (Wiley 2001a). Lack of accurate data for fish populations, patterns of occurrence, and habitats in all, or portions of, these drainages limits information on fish distribution, particularly native non-game fish, within the Project Area. Descriptions of the existing conditions for the Powder River Basin, Little Powder River Basin, Tongue River Basin, Belle Fourche River Basin, and Cheyenne River Basin follow.

Powder River Basin

The Powder River is a rare example of a free-flowing prairie stream. No dams exist over its entire length. Including tributaries, the drainage encompasses approximately 8,000 square miles. The South Fork Powder, Salt Creek, Clear Creek, and Crazy Woman Creek are major tributaries. Virtually all of the bottomland and riparian areas of the PRB are privately owned. Public lands, usually sagebrush or grasslands in uplands adjacent to the river, are managed by the BLM and are concentrated in the PRB about mid-way down the Powder River and in the upper reach of the South Fork Powder River (Bradshaw 1996).

Historically, the PRB was used extensively and almost exclusively for cattle and sheep grazing. Oil and gas developments and recently developed coal mines have become dominant land uses over the past 80 years (Bradshaw 1996).

Perennial streams in the PRB include the South Fork Powder River, Salt Creek, Crazy Woman Creek, and Clear Creek. Another 52 intermittent or ephemeral

tributaries to the Powder River also exist. Although species presence or abundance data are lacking for most of these seasonal tributaries, none support game fish and most are believed to hold no fish at all. Two of the native fish species that do occur, goldeye and sturgeon chub, are considered rare by the WGFD (Bradshaw 1996).

Native stream-dwelling gamefish are channel catfish, sauger, shovelnose sturgeon, and stonecat. Channel catfish, sauger, and shovelnose sturgeon occur most commonly below the mouth of Crazy Woman Creek as seasonal migrants from the Yellowstone River or the Powder River in Montana. Trout are found in the headwaters of South Fork Powder River, Willow Creek and Sanchez Creek (Bradshaw 1996).

The Powder River supports a diverse fish fauna of mostly native, nongame species, but specific life history information is lacking for most main stem Powder River fishes. Sturgeon chub, once endemic to several Wyoming rivers, but now found only in the Powder River, are considered rare by the WGFD. This species is not only adapted to turbidity, but apparently requires it because they are not found above the confluence of Salt Creek and the Powder River where turbidity is reduced. This spring spawner is found over swift rocky riffles throughout the Powder River (Bradshaw 1996).

Prior to 1978, the shovelnose sturgeon was considered rare; however, more recently it has been recognized as a fairly common seasonal migrant from the Yellowstone River in Montana. When they are present in the Powder River during the spring a small, but unknown, number of fish are taken by anglers. Shovelnose sturgeon are known to use Clear Creek and Crazy Woman Creek for spawning but, because of sampling difficulties, it is unknown if they use the Powder River for spawning or how far they ascend the river (Bradshaw 1996).

Basin geology is responsible for the river's reputation as a turbid, muddy stream. The Powder River has a typical snowmelt hydrograph driven by accumulations in the southern Bighorn Mountains. Peak flows occur from April through June and low flows occur from November through February. Flow variation is naturally high and is exacerbated by irrigation withdrawals throughout the drainage. Repeated withdrawal and return of irrigation water undoubtedly contributes to high summer temperatures that reach 85 to 90°F. Such high water temperatures are lethal to salmonids and may influence aquatic invertebrate diversity that has been characterized as low (Bradshaw 1996).

Though occasionally the river clears, it is typically very turbid during spring runoff and after storms. The river is generally shallow and contains portions of shifting streambed composed of fine sands and clays that provide minimal aquatic invertebrate habitat. Low light penetration through the turbid water also contributes to low aquatic invertebrate production by inhibiting vegetation growth (Bradshaw 1996).

Salt Creek is a major tributary of the Powder River and, during low flow periods, contributes the majority of the flow to the Powder River. Streamflows in Salt Creek are augmented by water discharged from oil and gas wells drilled in the Salt Creek Field near Midwest, Wyoming. This water contains elevated levels of

TDS, chlorides, sulfates, and sodium. Depending on the time of year, these constituents can be diluted fairly quickly after Salt Creek joins the Powder River, or may remain at elevated levels during low flow periods. Although fish in Salt Creek apparently do not suffer from elevated chemical constituents or the small amounts of oil found in the water, toxicity for zooplankton (*Cereodaphnia* spp.) and fathead minnows has been documented (Bradshaw 1996).

Extreme fluctuation in streamflow and temperature, low aquatic invertebrate production, high turbidity, and dissolved solids, and an unstable streambed limit the population visibility of salmonids and most Wyoming gamefish. Consequently, sportfish management options are limited. Similar conditions prevail in the tributaries of the Powder River (Bradshaw 1996).

Little Powder River Basin

The fish assemblage in the Little Powder River basin in northeast Wyoming is limited due to a lack of habitat and low flow. The northern three-fourths of the Little Powder River Basin is sagebrush steppe and ponderosa forest, whereas the southern one-fourth is mixed-grass prairie. Land use in the basin is primarily livestock grazing with hay production in the valleys and riparian areas (Stewart 1996).

The Little Powder River drainage covers 1,836 square miles. Roughly 10 percent of the drainage is public land, including National Grasslands, BLM, and State of Wyoming lands. Elevation in the drainage ranges from 3,340 feet at the Wyoming-Montana border to 4,900 feet on the Belle Fourche-Little Powder hydrographic divide near Gillette (Stewart 1996).

Flowing water in this drainage is restricted to three stream reaches, all of which are on private land. The Little Powder River and a short reach of the Dry Fork of the Little Powder River below its confluence with Moyer Springs Creek have perennial water. The only coldwater habitat in the drainage is Moyer Springs Creek, a 0.5 mile reach of stream that contains a wild brook trout population with flows usually less than one cfs. There is no perennial water in any of the other tributary streams in the drainage. There is only one small standing water lake, Weston Reservoir (Little Powder Reservoir), that is suitable for gamefish and on accessible public land (Stewart 1996).

Habitats for fish are very limited in this drainage due to the low mean annual water balance and overall small size of the ephemeral streams. During extreme low water periods, habitat may be restricted to large pools that become isolated when streamflows cease. Many standing waters do not consistently support fish populations due to drying or low water levels during drought periods. The low water levels contribute to winterkill or summer die-offs. Channel catfish populations exist in the lower Little Powder River, but because of the stream's small size the potential for a sport fishery is very low. There are several limiting factors in the Little Powder River Basin. Lack of water limits fish habitats and low-water conditions in standing waters and lack of perennial flow in most of the drainage limits sport fishery potential and indigenous fishes in the basin (Stewart 1996).

Upper Tongue River Basin

The Upper Tongue River drainage in northcentral Wyoming has a diverse fish assemblage. Streams in the headwaters contain Snake River cutthroat trout, rainbow, brown, and brook trout, whereas a reach of the lower river contains sauger and smallmouth bass. The headwaters of the Tongue River drainage originate on the east side of the hydrographic divide of the Bighorn National Forest. After the North and South Tongue Rivers join to form the main stem Tongue River, the flow is primarily east and north until the Tongue River flows into Montana. Standing waters in this basin are primarily privately owned ponds, many of which are unsuitable for supporting fish populations. Elevations in the Tongue River drainage vary from 3,470 feet to10,046 feet (Wiley 2001a).

The North and South Tongue watersheds are predominantly conifer and alpine meadows with extensive willow complexes in some riparian areas. Logging, livestock grazing, and road building have accelerated the natural erosion process that contributes silt to the system. The Tongue River flows through a canyon for several miles before exiting onto the plains near the Bighorn National Forest boundary at the town of Dayton. From Dayton to the state line, it flows through an alluvial floodplain. Land use on this floodplain is predominantly agriculture, but residential development and one coal mine also exist (Wiley 2001a).

The South Tongue and North Tongue watersheds are conducive to natural trout reproduction. Below the canyon, suitable mountain whitefish reproductive habitat exists, and the Lower Tongue River supports suitable spawning habitat for sauger, smallmouth bass, stonecats, rockbass and other native and non-native non-game species (Wiley 2001a). Although some of these streams support suitable trout spawning habitat, much of this drainage supports native and non-native game fish.

The absence or scarcity of deep pools in several of the headwater tributary streams limits the habitat diversity and potential for larger fish populations. Sedimentation limits natural fish and macroinvertebrate production in many streams, especially the upper North Tongue watershed. Irrigation diversions reduce flows on many streams, and these reduced flows usually occur during critical life stages of fish and macroinvertebrates. From Interstate 90 downstream to the border, irrigation diversions form barriers that impede seasonal upstream movements of channel catfish, sauger, and smallmouth bass, as well as certain nongame species. Fish, especially channel catfish, move downstream in the fall and winter into Tongue River Reservoir in Montana, and the barriers impede upstream movement during spring (Wiley 2001a).

Upper Belle Fourche River Basin

The Upper Belle Fourche River drainage has over 3,762 square miles in the basin. Elevations in the drainage range from 3,100 feet in the northeast corner of Crook County at the Wyoming-South Dakota state line to 6,645 feet at Warren Peak. The topography is mostly rolling grasslands and sagebrush, with the exception of the ponderosa pine-dominated forest in the Black Hills National Forest. The principal use of the drainage is for livestock grazing and hay production. Water diversions for irrigation are common. Other uses common in the drainage

include oil and gas production, timbering, mining for coal and bentonite, and recreation (Wiley 2001a).

Most of the streams are unsuitable for coldwater fish and offer limited potential for warmwater game fish, due to water diversion and lack of suitable habitat. Beaver ponds on some minimal flow streams provide localized trout habitat and many of the small streams in the Black Hills depend on beaver ponds to provide habitat for fish; however, flash flood events or heavy sedimentation periodically eliminate these ponds for fisheries. There are only four streams in the drainage that contain self-sustaining trout populations including Sand Creek, Spottedtail Creek, Cold Springs Creek, and Ogden Creek. The majority of the game fish potential exists in the numerous farm ponds and reservoirs, but many of these are subject to periodic winter or summer kills due to limited water availability. Many of the farm ponds and privately owned reservoirs contain stunted populations of bullhead or green sunfish. The largest lentic fishery in the drainage is Keyhole Reservoir (Wiley 2001a).

Suitable habitats for game fish are minimal in the Upper Belle Fourche River drainage, due to the small size and low flow of the Upper Belle Fourche River and its tributaries. Small reservoir impoundments are abundant in this drainage, and game fish habitats are restricted to small impoundments and to a relatively few stream segments. Fish habitats in many streams are mainly confined to pools that may be isolated during extreme low water conditions. Lentic water habitats are limited by drought periods, drawdowns for irrigation, and stock watering. Shallow depths of lentic habitat often limits overwintering for fish, periodically resulting in partial or complete winterkills (Wiley 2001a).

Existing limiting factors for the Upper Belle Fourche River Basin include low oxygen and high temperatures during periods of low flow, cattle grazing impacts (i.e., nutrient enrichment, and compacting and devegetation of upland and riparian areas leading to increased erosion and siltation), and exotic species invasion (Wiley 2001a).

Upper Cheyenne River Basin

The Upper Cheyenne River qualifies as one of Wyoming's free-flowing prairie streams because it is not dammed until it reaches Angostura Reservoir in South Dakota. The surface area of the basin is approximately 5,160 square miles. The basin contains the southern end of the Black Hills, the breaks of the Rochelle Hills south of Gillette, and the rolling hills and grasslands north of Lusk. Elevations range from 3,500 feet where the river enters South Dakota to 6,000 feet in the sand hills of Converse County. Sagebrush and grasslands are the predominant vegetation types in the basin, with ponderosa pine in the Black Hills and Rochelle Hills (Wiley 2001a).

Virtually all of the bottomland and riparian areas of the Cheyenne River are privately owned; however, about 45 percent of the basin is public land managed by the BLM, FS, and State Land and Farm Loan Office. Major land uses include oil and gas development, bentonite mining, and livestock grazing and associated irrigation diversions, reservoirs, and stock ponds (Wiley 2001a).

The Lower Cheyenne River becomes intermittent in most years. Because the Cheyenne River and major tributaries are intermittent most years, the drainage has been considered unsuitable for game fish, but Patton (1996) confirmed the presence of green sunfish and black bullhead in Beaver Creek. Within the Upper Cheyenne River drainage, there are 56 other tributaries considered by the WGFD as unsuitable to support game fish (Wiley 2001a).

The Upper Cheyenne River hydrograph is driven by low elevation snow accumulations, seasonal rainfall, and periodic storm events. Near the South Dakota state line, flows cease during most years. The repeated withdrawal, warming, and return of irrigation water undoubtedly contributes to high summer temperatures that reach 70 to 80°F during summer. The Cheyenne River and many of its tributaries flow through erodable shales, claystones, sandstones, and bentonite deposits. This underlying geology causes most basin streams to be generally turbid, particularly during runoff or after storm events. Turbidity prevents light penetration needed for growing aquatic vegetation, channel instability, and high temperatures probably inhibiting aquatic macroinvertebrate production and creating an environment hostile to fish species not adapted to such conditions (e.g., game fish) (Wiley 2001a).

Existing limiting factors for the Upper Cheyenne River Basin, such as extreme fluctuation in streamflow and temperature, low aquatic invertebrate production, and high turbidity, limit the ability of most streams to support game fish, particularly cold- and cool-water species. Little is known of the habitat requirements, relative abundance, or spatial distribution of indigenous fish in the Upper Cheyenne River Basin. There is presently no baseline against which to measure indigenous fish population trends. There have been repeated illegal introductions of green sunfish and black bullhead into waters where they become overabundant, precluding game species and native non-game species from some areas (Wiley 2001a).

Within the Project Area, major rivers, creeks, draws, lakes, and ponds support a variety of fish species. Table 3–46 shows the occurrence of fish species by watershed. The WDFG assigns status categories to native aquatic species (Wiley 2001b). These rankings are also listed in Table 3–46.

Table 3–47 lists preferred habitats for fish species identified to occur within the Project Area. Some species occur only in streams and rivers, others occur only in lakes and ponds, while others occur in all four habitat types. Table 3–47 indicates the preferred habitats only and all species could be found within any of the four habitats.

Threatened, Endangered, or Sensitive Species

Regional Characterization

This section briefly discusses the biology of species that have been afforded special status by federal and state agencies including USFWS, FS, BLM, and WGFD. The special status designations include:

Table 3–46 Occurrence of Fish Species by Sub-watershed

Fish Species	Sub-watershed																		
Common Name (scientific name)	Wyoming Native Species Status[3]	Little Bighorn River[2]	Upper Tongue River[1,2]	Middle Fork Powder River[1,2]	North Fork Powder River[1]	Upper Powder River[1,2]	South Fork owder River[1]	Salt Creek[1]	Crazy Woman Creek[1]	Clear Creek[1]	Middle Powder River[1]	Little Powder River[1]	Little Missouri River[1,2]	Antelope Creek[1]	Dry Fork Cheyenne River[1]	Upper Cheyenne River[1,2]	Lightning Creek[1]	Upper Belle Fourche River[1,2]	Middle North Platte Casper[2]
Black bullhead (*Ameirus melas*)(N)	NSS3		X										X	X	X	X	X	X	X
Black crappie (*Pomoxis nigromaculatus*)(I)						X													X
Bigmouth shiner (*Notropis dorsalis*)(N)	NSS4																		X
Brassy minnow (*Hybognathus hankinsoni*)(N)	NSS6					X				X	X		X						X
Brook trout (*Salvelinus fontinalis*)(I)		X	X	X									X			X		X	
Brown trout (*Salmo trutta*)(I)		X	X	X		X										X		X	X
Channel catfish (*Ictalurus punctatus*)(N)	NSS4		X			X			X		X		X			X		X	X
Common carp (*Cyprinus carpio*)(I)			X			X			X	X	X	X	X	X	X	X	X	X	X
Common shiner (*Luxilus cornutus*)(N)	NSS3																		X
Creek chub (*Semotilus atromaculatus*)(N)	NSS5		X			X	X			X	X							X	X
Emerald shiner (*Notropis lutrensis*)(I)						X													X
Fathead minnow (*Pimephales promelas*)(N)	NSS6	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X
Finescale dace (*Phoxinus neogaeus*)(N)	NSS1																	X	
Flathead chub (*Platygobio gracilis*)(N)	NSS3	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Gizzard shad (*Dorosoma cepedianum*)(N)																X			X
Golden shiner (*Notemigonus crysoleucas*)(I)																			X
Goldeye (*Wiodon alosodies*)(N)	NSS2					X			X	X	X	X	X						
Green sunfish (*Lepomis cyanellus*)(I)			X									X	X	X	X	X	X	X	X
Iowa darter (*Etheostoma exile*)(N)	NSS4																		X

Table 3–46 Occurrence of Fish Species by Sub-watershed

Fish Species	Sub-watershed																			
Common Name (scientific name)	Wyoming Native Species Status[3]	Little Bighorn River[2]	Upper Tongue River[1,2]	Middle Fork Powder River[1,2]	North Fork Powder River[1]	Upper Powder River[1,2]	South Fork owder River[1]	Salt Creek[1]	Crazy Woman Creek[1]	Clear Creek[1]	Middle Powder River[1]	Little Powder River[1]	Little Missouri River[1,2]	Antelope Creek[1]	Dry Fork Cheyenne River[1]	Upper Cheyenne River[1,2]	Lightning Creek[1]	Upper Belle Fourche River[1,2]	Middle North Platte Casper[2]
Johnny darter (*Etheosoma nigrum*)(N)	NSS7																		X
Lake chub (*Couesius plumbeus*)(N)	NSS3		X										X					X	X
Lake trout (*Salvelinus namaycush*)(I)						X													
Largemouth bass (*Micropterus salmoides*)(I)		X											X			X		X	
Longnose dace (*Rhinichthys cataractae*)(N)	NSS7	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	
Longnose sucker (*Catostomus catostomus*)(N)	NSS4		X	X	X	X			X	X	X	X							X
Mosquitofish (*Gambusia affinis*)(I)																X	X		
Mountain sucker (*Catostomus platyrhynchus*)(N)	NSS3	X	X	X	X	X	X		X		X							X	
Mountain whitefish (*Prosopium williamsoni*)(N)	NSS4	X	X																
Northern redhorse (*Maxostoma macrolepidotum*)(N)	NSS4		X			X			X	X	X	X	X					X	X
Plains killifish (*Fundulus zebrinus*)(N)	NSS6					X	X				X			X	X	X	X		
Plains minnow (*Hybognathus placitus*)(N)	NSS3		X			X	X	X		X	X	X		X	X	X	X	X	
Quillback (*Carpiodes cyprinus*)(N)	NSS4																	X	X
Rainbow trout (*Oncorhynchus mykiss*)(I)		X	X			X							X			X		X	X
Red shiner (*Cyprinella lutrensis*)(N)	NSS7																	X	X
River carpsucker (*Carpiodes carpio*)(N)	NSS4					X			X	X	X			X	X	X	X	X	X
Rock bass (*Ambloplites rupestris*)(I)			X			X				X	X								
Sand shiner (*Notropis stramineus*)(N)	NSS7		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sauger (*Stizostedion canadense*)(N)	NSS2		X																

Table 3–46 Occurrence of Fish Species by Sub-watershed

Fish Species	Sub-watershed																			
Common Name (scientific name)	Wyoming Native Species Status[3]	Little Bighorn River[2]	Upper Tongue River[1,2]	Middle Fork Powder River[1,2]	North Fork Powder River[1]	Upper Powder River[1,2]	South Fork owder River[1]	Salt Creek[1]	Crazy Woman Creek[1]	Clear Creek[1]	Middle Powder River[1]	Little Powder River[1]	Little Missouri River[1,2]	Antelope Creek[1]	Dry Fork Cheyenne River[1]	Upper Cheyenne River[1,2]	Lightning Creek[1]	Upper Belle Fourche River[1,2]	Middle North Platte Casper[2]
Silvery minnow (*Hybognathus nuchalis*)(N)	NSS1											X	X						
Smallmouth bass (*Micropterus dolomieui*)(I)		X			X				X	X		X			X		X		
Snake River cutthroat trout (*Oncorhynchus clarki ssp.*)(N)	NSS4	X													X		X		
Spottail shiner (*Notropis hudsonius*)(I)																		X	
Stonecat (*Notorus flavus*)(N)	NSS4	X		X	X			X	X	X	X	X					X	X	
Stoneroller (*Campostoma anomalum*)(N)	NSS4																	X	
Sturgeon chub (*Macrhybopsis gelida*)(N)	NSS1				X			X		X									
Walleye (*Stizostedion vitreum*)(I)		X			X										X		X	X	
White crappie (*Pomoxis annularis*)(I)		X																X	
White sucker (*Catostomus commersoni*)(N)	NSS7	X		X	X		X	X	X	X	X				X	X	X	X	
Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*)(N)	NSS2	X																	
Yellow perch (*Perca flavescens*)(I)		X	X														X	X	

Notes:

1. Data from Patton, 1997.
2. Data from Wyoming Game and Fish Basin Management Plans (Wiley 2001a). (I) = Introduced species in Wyoming. (N) = Native species in Wyoming.
3. Status 1 Species – Populations are physically isolated and/or exist at extremely low densities throughout range. Habitats are declining or vulnerable. Extirpation appears possible. The Wyoming Game and Fish Commision mitigation category is "Vital". The mitigation objective for this resource category is to realize "no loss of habitat function". Under these guidelines, it will be very important that the project be conducted in a manner that avoids alteration of habitat function. Status 2 Species - Populations are physically isolated and/or exist at extremely low densities throughout range. Habitat conditions appear stable. The Wyoming Game and Fish Commision mitigation category is "Vital". Status 3 Species – Populations are widely distributed throughout its native range and appear stable. However, habitats are declining or vulnerable. The Wyoming Game and Fish Commision mitigation category is "High". The mitigation objective for this category is to realize "no net loss of habitat function within the biological community which encompasses the project site". Under these guidelines, it will be important that the project be conducted in a manner that avoids the impact, enhances similar habitats, or results in the creation of an equal amount of similarly valued fishery habitat. Status 4-7 Species – Populations are widely distributed throughout native range and are stable or expanding. Habitats are also stable. There is no special concern for these species.

Table 3–47 Preferred Habitats of Fish Species

Common Name	Habitat Types[1] Streams and Rivers (Lotic)	Ponds and Lakes (Lentic)	All Habitats (Lotic and Lentic)	Specific Preferred Habitats
Black bullhead			X	prefers small muddy lakes; found in pools in large and small streams
Black crappie		X		
Bigmouth shiner			X	prefers sandy streams; sometimes in lakes
Brassy minnow			X	weedy streams, clear creeks with sand and gravel bottoms; occasionally in lakes
Brook trout			X	prefers small, cold streams and beaver ponds; mountain lakes; plains lakes occasionally
Brown trout	X			prefers larger foothill streams with slower-moving waters; rarely does well in lakes
Channel catfish			X	prefers large clear rivers; tolerates turbid water; game fish in lakes
Common carp			X	lakes; pools and backwaters in rivers
Common shiner	X			prefers clear, gravel-bottomed streams
Creek chub	X			prefers clear, gravel-bottomed creeks
Emerald shiner	X			
Fathead minnow			X	prefers smaller streams, many ponds, and some lakes
Finescale dace			X	prefers cool, weedy, small streams, ponds, and small lakes
Flathead chub	X			prefers large silty rivers
Gizzard shad			X	prefers larger streams and reservoirs
Golden shiner			X	prefers standing or slowly moving water with abundant vegetation
Goldeye			X	prefers lakes and streams, adapted for turbidity
Green sunfish			X	prefers pools in small to medium-sized streams, small lakes, ponds, and sloughs
Iowa darter			X	prefers clear, cool, weedy streams, lake shorelines
Johnny darter	X			prefers small, stream-red, high gradient streams
Lake chub			X	prefers cool foothill streams and sometimes lakes
Lake trout		X		prefers cold, deep lakes
Largemouth bass			X	prefers lakes and backwaters of streams
Longnose dace	X			prefers riffles in small and large streams
Longnose sucker			X	prefers cold water lakes, streams and rivers
Mosquitofish			X	prefers streams and lakes
Mountain sucker			X	prefers larger creeks and rivers, alpine lakes

Table 3–47 Preferred Habitats of Fish Species

Common Name	Habitat Types[1] Streams and Rivers (Lotic)	Ponds and Lakes (Lentic)	All Habitats (Lotic and Lentic)	Specific Preferred Habitats
Mountain whitefish	X			prefers large, cold, clear rivers
Northern redhorse			X	prefers medium-sized streams and small lakes
Plains killifish	X			prefers shallow sandy streams
Plains minnow	X			prefers slower water and side pools in silty streams
Quillback	X			
Rainbow trout			X	
Red shiner	X			prefers medium-sized streams in medium current
River carpsucker	X			prefers clear and turbid rivers and streams
Rock bass	X			prefers pools in streams
Sand shiner	X			prefers permanent sandy streams
Sauger			X	prefers large rivers and reservoirs
Silvery minnow	X			prefers larger rivers
Smallmouth bass			X	prefers cool, clear rivers and large, cool, clear lakes
Snake River cutthroat trout	X			prefers swift streams
Spottail shiner			X	prefers large rivers and lakes
Stonecat	X			prefers rubble-bottomed streams
Stoneroller	X			prefers small streams tributary to North and South Platte Rivers
Sturgeon chub	X			prefers large, silty rivers
Walleye			X	prefers lakes and rivers
White crappie		X		
White sucker			X	prefers lakes and streams, avoid current
Yellowstone cutthroat trout	X			
Yellow perch		X		

Sources: Baxter and Simon 1970, Woodling 1985

- Species listed as threatened or endangered, proposed for listing as threatened or endangered, or considered as a candidate for listing as threatened or endangered by the USFWS,
- Species listed as sensitive by the BLM or FS, and
- Species categorized by WGFD as SSC1-6. WGFD recognizes six classes of special concern, of which classes 1, 2, and 3 are considered to be high priorities for conservation.

The USFWS is directed by the ESA to identify and protect threatened and endangered plant and animal species. The ESA identifies the following categories to rank listed and candidate species.

The term "endangered species" means any species that is in danger of extinction throughout all or a significant portion of its range [(ESA §3(6)]. In addition to determining that a species will be listed as endangered, the USFWS may also designate critical habitat for a species as defined in section 3(5) of the ESA [ESA §4(b)(6)(C)].

Except as provided in sections 6(g)(2) and 10 of the ESA, with respect to any endangered species of fish or wildlife listed pursuant to section 4 of the ESA it is unlawful for any person subject to the jurisdiction of the United States to import, export, take, possess, deliver, receive, carry, transport, ship, or sell or offer for sale any such species, or violate any regulation pertaining to such species [ESA §9(a)(1)(A-G)]. The term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct [ESA §3(18)].

Except as provided in sections 6(g)(2) and 10 of the ESA, with respect to any endangered species of plant listed pursuant to section 4 of the ESA it is unlawful for any person subject to the jurisdiction of the United States to import, export, remove and reduce to possession, maliciously damage or destroy, remove, cut, dig up, deliver, receive, carry, transport, ship, or sell or offer for sale any such species, or violate any regulation pertaining to such species [ESA §9(a)(2)(A-E)].

The term "threatened species" means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range [ESA §3(19)]. In addition to determining that a species will be listed as threatened, the USFWS may also designate critical habitat for a species as defined in section 3(5) of the ESA [ESA §4(b)(6)(C)].

Whenever a species is listed as threatened pursuant to section 4(c) of the ESA, the USFWS shall issue such regulations as deemed necessary and advisable to provide for the conservation of such species. The USFWS may by regulation prohibit any act prohibited under section 9(a)(1) for fish and wildlife species, or section 9(a)(2) for plant species with respect to endangered species [ESA §4(d)]. In general, equivalent protections are given for threatened species as are given for endangered species, based on the USFWS' implementing regulations for threatened species (50 CFR 17.31).

Proposed species are those species for which the USFWS has published a proposed rule for listing under the provisions of section 4(b)(5) of the ESA. The USFWS has 12 months to act on such a proposal, although this period may be extended in cases where additional information is needed to complete the listing package, or where other priorities cause the postponement of completion of the listing package.

Candidate species are those species for which the USFWS has sufficient information on biological vulnerability and threats to warrant issuance of a proposed rule for listing, but for which publication of a proposed rule for listing is precluded by other higher priority listing actions ("warranted but precluded"). The candidate list also includes all species for which a petition finding of warranted but precluded has been issued. For example, a petition was submitted to the USFWS requesting that the black-tailed prairie dog be listed as threatened. The USFWS

has ruled that it has sufficient information to list the blacck-tailed prairie dog, but that other listing priorities preclude the issuance of a proposal to list the black-tailed prairie dog. The candidate list is reviewed on an annual basis, most recently in findings issued on October 30, 2001.

Candidate species are not afforded any federal statutory protections until such a time as a proposed rule for listing is published. Nevertheless, candidate species are often considered during project development in order to avoid the need for additional consultation and the potential for project delays in the event that a species is proposed for listing, or listed, prior to project completion.

The National Forest Management Act includes provisions which state that the maintenance of biodiversity must be considered in managing National Forest lands. Forest Service Manual 2670.22 requires the FS to maintain viable populations of all native and desired non-native wildlife, fish, and plants in habitats distributed throughout their geographic range on National Forest System lands. In recognition of the need to specially manage rare plants and animals on the lands that it administers, the FS designates certain species as sensitive. Specific management requirements and standards are often implemented for sensitive species in individual Forest Plans. The FS sensitive species are provided protection only in situations where the agency has some control over activities.

The FLPMA requires that the BLM manage the public lands in a manner that will protect the quality of scientific, ecological, and environmental values (including native plants and animals) and that will protect certain public lands in their natural condition.

BLM Manual 6840 states that it is BLM policy to carry out management consistent with the principles of multiple use for the conservation of candidate plant and animal species and their habitats and to ensure that actions authorized, funded, or carried out do not contribute to the need to list any of these species as threatened or endangered.

The BLM has developed a sensitive species policy and list for public lands in Wyoming. Under this policy, State Directors may designate sensitive species, usually in cooperation with the State wildlife agency. By definition, the sensitive species designation includes species that could easily become endangered or extinct in the state. Therefore, if sensitive species are designated by the State Director then the protection provided by the policy for candidate species shall be used as the minimum level of protection.

The WGFD has developed a matrix of habitat and population variables to determine the conservation priority of all native, breeding bird, and mammal species in the state. Six classes of Species of Special Concern (SSC) are recognized, of which classes 1, 2, and 3 are considered to be high priorities for conservation attention. These three highest priority designations are defined here.

SSC1: Includes species with ongoing significant loss of habitat and with populations that are greatly restricted or declining (extirpation appears possible).

SSC2: Species in which (1) habitat is restricted or vulnerable (but no recent or significant loss has occurred) and populations are greatly restricted or declining; or (2) species with on-going significant loss of habitat and populations that are declining or restricted in numbers and distribution (but extirpation is not imminent).

SSC3: Species in which (1) habitat is not restricted, but populations are greatly restricted or declining (extirpation appears possible); or (2) habitat is restricted or vulnerable (but no recent or significant loss has occurred) and populations are declining or restricted in numbers or distribution (but extirpation is not imminent); or (3) significant habitat loss is on-going but the species is widely distributed and population trends are thought to be stable.

SSC4: Species in which (1) populations are declining or restricted in numbers and/or distribution but extirpation is not imminent; and/or habitat is not restricted or vulnerable (but no recent or significant loss has occurred) and species is not sensitive to human disturbance; or (2) species is widely distributed, population status or trends are unknown but are suspected to be stable; habitat is restricted or vulnerable but no recent or on-going significant loss; species may be sensitive to human disturbance.

Much of the information available for the following special status species is restricted to public lands, including lands administered by BLM, FS, and USFWS. Unfortunately, similar information is generally not available for privately owned lands. Therefore, the occurrence of the following special status species is unverified for much of the privately owned lands within the Project Area. Although unverified, sensitive species will be assumed to occur in all suitable habitats within the Project Area, despite land ownership, for the purpose of this assessment.

Special-Status Plant Species

U.S. Fish and Wildlife Service

Ute ladies'-tresses Orchid

Ute ladies'-tresses orchid (*Spiranthes diluvialis*), listed as a federally threatened species, is a perennial herb with erect, glandular-pubescent stems 12 to 50 centimeters tall arising from tuberous-thickened roots (USFWS 1992). This species flowers from late July to September. Plants probably do not flower every year and may remain dormant below ground during drought years. It is currently known from western Nebraska, southeastern Wyoming, north-central Colorado, northeastern and southern Utah, east-central Idaho, southwestern Montana, and central Washington. In Wyoming, Ute ladies'-tresses orchid is known from the western Great Plains in Converse, Goshen, Laramie, and Niobrara counties. Rangewide, Ute ladies'-tresses orchid occurs primarily on moist, subirrigated or seasonally flooded soils in valley bottoms, gravel bars, old oxbows, or floodplains bordering springs, lakes, rivers, or perennial streams at elevations between 1,780 and 6,800 feet elevation (Fertig and Beauvais 1999). Suitable soils vary from sandy or coarse cobbley alluvium to calcareous, histic, or fine-textured

clays and loams. Populations have been documented from alkaline sedge meadows, riverine floodplains, flooded alkaline meadows adjacent to ponderosa pine, Douglas fir woodlands, sagebrush steppe, and streamside floodplains. Some occurrences are also found on agricultural lands managed for winter or early season grazing or hay production. Known sites often have low vegetative cover and may be subjected to periodic disturbances such as flooding or grazing. Populations are often dynamic and "move" within a watershed as disturbances create new habitat or succession eliminates old habitat (Fertig and Beauvais 1999).

This species is known from four occurrences in Wyoming, all discovered between 1993-1997 (Fertig and Beauvais 1999). One of these occurrences is recorded from northwestern Converse County and is included within the Project Area. This species is expected to occur in suitable habitats within the Project Area.

Wyoming BLM and Forest Service

Some of the following species that follow are not expected to occur within the Project Area. They are included because these species are on the BLM and FS candidate and sensitive species lists and occur near the Project Area.

Laramie Columbine

Laramie columbine (*Aquilegia laramiensis*) is listed as a sensitive species by Wyoming BLM and Region 2 FS. This species is a perennial, leafy, many-stemmed herb 10 to 20 centimeters tall. This species flowers and fruits from June to August. The Laramie columbine is endemic to the Laramie Range of southeast Wyoming (Albany and Converse counties). It is often found in shady crevices of north-facing granite boulders and cliffs with pockets of rich soil between 6,250 and 8,000 feet elevation (Fertig and Beauvais 1999).

Laramie columbine is known from the eight extant populations all restricted to extreme southern Converse county and northern Albany county (Fertig and Beauvais 1999). These documented occurrences are not included within the Project Area but, this species is expected to occur in suitable habitats within the Project Area.

Porter's Sagebrush

Porter's sagebrush (*Artemisia porteri*) is listed as a sensitive species by Wyoming BLM. This species is a mat-forming perennial subshrub with numerous slender stems less than 15 centimeters tall. This species flowers in June and July. Porter's sagebrush is endemic to Wyoming and is restricted to the Wind River Basin and Powder River Basin in Fremont, Johnson, and Natrona counties. Suitable habitat includes sparsely vegetated badlands of ashy or tufaceous mudstones and clay slopes between 5,300 and 6,500 feet elevation. In the northern Wind River Basin, this species is found in semi-barren, low desert shrub communities dominated by Porter's sagebrush, birdfoot sagebrush, longleaf wormwood on dry, whitish, ashy-clay hills, gravelly-clay flats, and shaley erosional gullies of the Wagon Bed Formation (Fertig and Beauvais 1999).

Porter's sagebrush is known from eight extant populations in Fremont, Johnson, and Natrona counties (Fertig and Beauvais 1999). A single population docu-

mented in southwestern Johnson County is within the Project Area, and this species is expected to occur in suitable habitats within the Project Area.

Nelson's Milkvetch

Nelson's milkvetch (*Astragalus nelsonianus*) is listed as a sensitive species by Wyoming BLM. This species is a perennial herb with fleshy-leathery stems 10 to 30 centimeters tall. This species flowers from mid-May to late June. Nelson's milkvetch is regionally endemic to southwest and central Wyoming, northeast Utah, and northwest Colorado. In Wyoming, it is known from the Wind River, Green River, Washakie, southern Powder River, and Great Divide basins, Owl Creek Mountains, and the Rock Springs Uplift in Fremont, Natrona, and Sweetwater counties. Suitable habitat for this species includes alkaline, often seleniferous, clay flats, shale bluffs and gullies, pebbly slopes, and volcanic cinders. Known occurrences are found primarily in sparsely vegetated sagebrush, juniper, and cushion plant communities at elevations between 5,200 and 7,600 feet elevation (Fertig and Beauvais 1999).

This species is known from 24 extant populations all located on private lands within central Wyoming (Fertig and Beauvais 1999). Three populations are known from Johnson County, two of which are located in the eastern portion of the county that is within the Project Area. Therefore, this species is expected to occur in suitable habitats within the Project Area.

Many-stemmed Spider-Flower

Many-stemmed spider-flower (*Cleome multicaulis*) is listed as a sensitive species by Wyoming BLM. This species is a slender, glabrous annual forb with erect, unbranched or sparingly branched leafy stems 20 to 70 centimeters tall. This species flowers and sets fruit from June to August. Its global distribution includes central Mexico (near Mexico City) to southeast Arizona, southwest New Mexico, and southwest Texas, with disjunct populations in south-central Colorado and central Wyoming. Wyoming populations are restricted to the Sweetwater River Valley in Natrona County. In Wyoming, Many-stemmed spider-flower is found primarily on whitish, alkali-rich, strongly hydrogen-sulfide scented soils bordering shallow, spring-fed playa lakes or dried lakebeds. Populations are most abundant on damp, but not flooded, flats with approximately 90 percent cover of alkali-cordgrass, desert saltgrass, balti rush, Nuttall's alkaligrass, Nevada bulrush, and sea arrowgrass bordering playa lakes. This species may also be present in lower numbers on clayey dunes surrounding alkaline lakes with less than 50 percent cover of cordgrass, arrowgrass, and alkali sacaton or on low hummocks of greasewood. Small patches may also occur in dry alkaline depressions with 20 percent cover of saltgrass, cordgrass, plains sea-blite, smoot hawk's beard, and goldenweed. All Wyoming colonies occur at about 5,860 feet elevation (Fertig and Beauvais 1999).

This species is known from a single extant site in Natrona County (Fertig and Beauvais 1999). Because all known Wyoming populations of this species occur in Natrona County, this species is not expected to occur within the Project Area.

Williams' Wafer-Parsnip

Williams' wafer-parsnip (*Cymopterus williamsii*) is listed as a sensitive species by Wyoming BLM. This species is a tufted, perennial herb with basal, once-pinnately compound leaves and a flowering stalk five to ten centimeters tall. This species flowers from May through mid-June. Williams' wafer-parsnip is endemic and restricted to the Bighorn Mountains of north-central Wyoming in Bighorn, Johnson, Natrona, and Washakie counties. Suitable habitat includes open, south or east-facing ridgetops and upper slopes with exposed limestone outcrops or talus between 6,000 and 8,300 feet elevation. Soils tend to be thin, sandy, and often restricted to small cracks or pockets in limestone bedrock. Barren rock can provide up to 50 percent of total cover. This species is usually absent or very uncommon where grass cover is high or where western mountain mahogany and ponderosa pine are dominant. It also tends to be absent from lower slopes or valley bottoms with deeper or better-developed soils. Common associates include timber milkvetch, spatulate milkvetch, alpine bladderpod, whitlow-wort, and stemless hymenoxys (Fertig and Beauvais 1999).

This species is known from 23 extant populations found in the limestone or talus outcrops of the Bighorn Mountains (Fertig and Beauvais 1999). This species may occur in suitable habitats in Johnson County and, therefore, may occur within the Project Area.

Cary Beardtongue

Cary beardtongue (*Penstemon caryi*) is listed as a sensitive species by Wyoming BLM and Region 2 of the FS. This species is a glabrous perennial herb with flowering stems 10 to 40 centimeters tall. The flowering period for the Cary beardtongue is between May and July. This species is a regional endemic of the Bighorn and Pryor Mountains of north-central Wyoming (Big Horn, Sheridan, and Washakie counties) and south-central Montana. Suitable habitat for this species includes sparsely-vegetated calcareous rock outcrops and rocky soil within sagebrush, juniper, Douglas-fir, and limber pine communities. This species typically occurs at elevations between 5,200 and 8,500 feet. Observations in Wyoming suggest that the species does not favor areas of dense grass or shrub cover (Fertig and Beauvais 1999).

This species is known from 15 extant populations in the Bighorn Mountains (Fertig and Beauvais 1999). Four of these known populations occur in extreme western Sheridan County that is not within the Project Area. Therefore, this species is not expected to occur in the Project Area.

Laramie False-Sagebrush

Laramie false-sagebrush (*Sphaeromeria simplex*) is listed as a sensitive species by Wyoming BLM and Region 2 of the FS. This species is a mat-forming perennial herb or subshrub less than ten centimeters tall. This species flowers between May and August. It is endemic to southeast Wyoming in the western foothills of the Laramie Range, Shirley Basin, and Shirley Mountains (Albany, Carbon, Converse, and Natrona counties) (Fertig and Beauvais 1999).

This species is known from 11 extant populations that occur in Albany, Carbon, Converse, and Natrona counties (Fertig and Beauvais 1999). All of the known

populations in Converse County occur in the southern portion of the county and south of the southern extent of the Project Area. Therefore, this species is not expected to occur within the Project Area.

Soft Aster

Soft aster (*Aster mollis*) is listed as a sensitive species by Region 2 of the FS. This species is a perennial, multi-stemmed herb averaging 30 to 50 centimeters high. This species flowers between July and mid-September. Soft aster is a Wyoming endemic restricted to the Bighorn Mountains (Big Horn, Johnson, Natrona, Sheridan, and Washakie counties) and Cliff Creek/Hoback Canyon area of Sublette County (Fertig et al. 1994). Jones (1984) also reports a specimen *of purple aster* from Fremont County "with possible influence of soft aster". Potential habitat may extend into Montana at the far northern end of the Bighorn Mountains in the Crow Indian Reservation. Suitable habitat for the soft aster includes primarily deep, rocky calcareous soils in dry mountain big sagebrush or shrubby cinquefoil grasslands and mountain meadows bordered by aspen or conifer woods at 6,400-8,500 feet elevation. Populations have also been documented from limestone outcrops and redbeds.

This species is known to occur from 34 extant populations found in the Bighorn Mountains (Fertig and Beauvais 1999). The documented populations found in Sheridan and Johnson counties are near the western boundary of the Project Area. Therefore, this species may occur in suitable habitats within the Project Area.

Northern Arnica

Northern arnica (*Arnica lonchophylla*) is listed as a sensitive species by Region 2 of the FS. This species is a perennial herb with solitary or loosely-clustered, glandular-hairy stems 17 to 40 centimeters tall. This species flowers in June and July. Its global distribution is from Alaska to Newfoundland, south to southern Alberta, Minnesota, and New Brunswick, with disjunct populations in Wyoming and South Dakota; these have been segregated as var. *arnoglossa* by some authors. In Wyoming, northern arnica is known from the Bighorn Mountains in Johnson, Sheridan, and Big Horn counties, with a vague, historical report from Washakie County. Suitable habitat in Wyoming is subalpine granite talus slopes and rocky meadows, montane limestone or granite talus slopes, montane Douglas-fir, limber pine, or Engelmann spruce slopes covered by dense moss, and Engelmann spruce riparian woods on mossy knolls and boulders between 5,300 to 10,300 feet elevation (Fertig and Beauvais 1999).

Northern arnica is known from nine extant occurrences in Wyoming with seven occurrences discovered since 1992 (Fertig and Beauvais 1999). The documented populations found in Sheridan and Johnson counties are near the western boundary of the Project Area. Therefore, this species may occur within the Project Area.

Hall's Fescue

Hall's fescue (*Festuca hallii*) is listed as a sensitive species by Region 2 of the FS. This species is a tufted perennial with stems (culms) 20 to 80 centimeters tall. The flowering period for this species is between May and July. Its distribution is

from northern Alberta to Ontario, south to North Dakota and Colorado. In Wyoming, it is known from the Absaroka, Beartooth, Bighorn, and Medicine Bow Mountains in Albany, Johnson, and Park counties. Suitable habitat includes montane meadows, slopes, and edges of open coniferous woods and meadows at 6,800 to 11,000 feet elevation, usually on soils derived from calcareous parent material. It can occur at the edge between open meadows and lodgepole pine-Englemann spruce forests or in tundra. This species occurs with shrubby cicngue-foil, big sagebrush, timber eoatgrass, prairie lupine, prairie smokemountain death-camas, beardtongue spp. (Fertig and Beauvais 1999).

This species is known from ten confirmed records, eight of which are from Park County, and one from Johnson and Albany counties (Fertig and Beauvais 1999). One documented population in Johnson County occurs near the western border of the county, west of the Project Area. Because of the lack of suitable habitat conditions and the absence of any known occurrences within the Project Area, this species is not expected to occur within the Project Area.

Northern Blackberry

Northern blackberry (*Rubus acaulis*) is listed as a sensitive species by Region 2 of the FS. This species is a low, rhizomatous, perennial herb with non-bristly/prickly stems to 15 centimeters high. The flowering period for this species is from mid-June to July. Its global distribution is from Alaska to Newfoundland south to British Columbia and Minnesota, and in the Rocky Mountains from Montana to Colorado. In Wyoming, it is known from the east slope of the Bighorn Mountains (Johnson County) and Yellowstone Plateau (Teton County). Suitable habitat is in understory of moderate to dense canopy cover in spruce, spruce/willow, and occasionally willow-dominated communities (Fertig and Beauvais 1999).

This species is known from three extant populations, two populations in the Bighorn Mountains of northwestern Johnson County, and one population in Teton County (Fertig and Beauvais 1999). The known occurrences of this species do not occur within the Project Area. Because of the lack of suitable habitat conditions and the absence of any known occurrences within the Project Area, this species is not expected to occur within the Project Area.

Hapeman's Sullivantia

Hapeman's sullivantia (*Sullivantia hapemanii* var. *hapemanii*) is listed as a sensitive species by Region 2 of the FS. This species is a perennial forb with glandular-pubescent stems 5 to 60 centimeters tall. This species flowers from June to August. It is a regional endemic of southern Montana, north-central Wyoming, and central Idaho. In Wyoming, it is known from the Bighorn Mountains, Wind River Canyon, and northern Laramie Mountains in Big Horn, Johnson, Sheridan, Washakie, Hot Springs, and Natrona counties. Suitable habitat is considered moist calcareous outcrops and boulders in shady canyons and streams at 4,600 to 8,200 feet elevation (Fertig and Beauvais 1999).

This species is known from 26 extant populations near the Bighorn Mountains (Fertig and Beauvais 1999). The documented occurrences of this species in Sheridan and Johnson counties are near the western boundary of the Project

Area. Therefore, this species may occur in suitable habitats within the Project Area.

Special-Status Terrestrial Wildlife Species

Much of the information available for the following special status species is restricted to public lands, including lands administered by BLM, FS, and USFWS. Unfortunately, similar information is generally not available for privately owned lands. Therefore, the occurrence of the following special status species is unverified for much of the privately owned lands within the Project Area. Two published reports from the WGFD, *Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming* (Luce et al. 1999) and *Threatened, Endangered, and Nongame Bird and Mammal Investigations* (Cerovski et al. 2000) were relied upon heavily for general species occurrence information within the Project Area. Unless otherwise noted, these special status species are expected to utilize suitable habitats within the Project Area.

Some of the following species that follow are not expected to occur within the Project Area. They are included because these species are on the BLM and FS candidate and sensitive species lists and occur near the Project Area.

U.S. Fish and Wildlife Service

Black-tailed Prairie Dog

Black-tailed prairie dog (*Cynomys ludovicianus*) was added to the list of candidate species for federal listing on February 4, 2000 (USFWS 2000a). At that time, the USFWS concluded that listing the black-tailed prairie dog was warranted but precluded by other higher priority actions to amend the lists of threatened and endangered species. No specific date for proposal for listing was given, but the USFWS has committed to reviewing the status of the species one year after publication of the above-mentioned notice (i.e. on February 4, 2001) (USFWS 2000b). As of October 2001, the candidate status of the black-tailed prairie dog status had not been changed by the USFWS (USFWS 2001d).

The black-tailed prairie dog is a highly social, diurnally active, burrowing mammal. Aggregations of individual burrows, known as colonies, form the basic unit of prairie dog populations. Found throughout the Great Plains in shortgrass and mixed-grass prairie areas (Fitzgerald et al. 1994), the black-tailed prairie dog has declined in population numbers and extent of colonies in recent years due to habitat destruction or disturbance, and pest control activities. In Wyoming, this species is primarily found in isolated populations in the eastern half of the state (Clark and Stromberg 1987). Many other wildlife species, such as the black-footed ferret, swift fox, mountain plover, ferruginous hawk, and burrowing owl are dependant on the black-tailed prairie dog for some portion of their life cycle (USFWS 2000b).

This species is considered a common resident, utilizing shortgrass and mid-grass habitats in eastern Wyoming (Luce et al. 1999). Active and inactive prairie dog colonies are known to occur within the Project Area. However specific population and occurrence pattern data are not available.

Preble's Meadow Jumping Mouse

Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (PMJM) is a federally-listed threatened species, endemic to the Colorado Piedmont east of the Front Range in east-central Colorado, along the Laramie Mountains in southeastern Wyoming, and following the North Platte River to Douglas, Wyoming (USFWS 2001e). The subspecies has declined within its historic range most likely due to habitat destruction from urbanization, livestock grazing, and water diversions.

Little is known about the habitat requirements of PMJM except what has been revealed in recent unpublished reports and anecdotal information from small mammal studies in riparian areas. Apparently, this subspecies is restricted to multi-strata, stream-side vegetation often in association with willows (*Salix* spp.) and in areas of thick herbaceous undergrowth. Other studies of meadow jumping mice in the eastern half of North America have reported habitat associations with grassy vegetation of adequate herbaceous ground cover (Whitaker 1963) and moist lowlands areas as opposed to mesic uplands (Quimby 1951).

In Wyoming, PMJM have been documented in two counties: along Crow Creek at F.E. Warren Air Force Base (Laramie County), and in the Lodgepole Creek drainage within the Medicine Bow National Forest (Albany County) (USFWS 2001e). Northern and eastern distribution limits for this species are not firmly established. A recent report published by Wyoming Natural Diversity Database states this species has been documented in the North Platte and South Platte Riverbasins, with collection sites as far north as the town of Douglas, west to the town of Boxelder, and east to the vicinity of Slater (Beauvais 2001). This report also states that surveys for members of the same genus on the FS Thunder Basin National Grasslands were conducted in 2000 with no captures. Therefore, this species is not expected to occur within the Project Area.

Black-footed Ferret

Black-footed ferret (*Mustela nigripes*) is a federally-listed endangered species. The black-footed ferret historically occurred throughout Texas, Oklahoma, New Mexico, Arizona, Utah, Kansas, North and South Dakota, Montana, Wyoming, Nebraska, and Colorado (USFWS 1970). The black-footed ferret is closely associated with prairie dogs, depending almost entirely upon the prairie dog for its survival. The decline in ferret populations has been attributed to the reduction in the extensive prairie dog colonies that historically existed in the western United States. Ferrets may occur within colonies of white-tailed or black-tailed prairie dogs. The USFWS has determined that, at a minimum, potential habitat for the black-footed ferret must include a single white-tailed prairie dog colony of greater than 200 acres, or a complex of smaller colonies within a 4.3 mile (7 km) radius circle totaling 200 acres (USFWS 1989). Minimum colony size for black-tailed prairie dog is 80 acres (USFWS 1989). The last known wild population was discovered in Meeteetse, Wyoming. Individuals from this population were captured and raised in protective captive breeding facilities in an effort to prevent the species' extinction (Clark and Stromberg 1987).

Recent survey efforts in the Shirley Basin have identified a population at this former re-introduction site. This is the only known population in Wyoming

(Marinari 2001). Extensive efforts have failed to identify any existing wild populations of this species within the Project Area. This species is not expected to occur within the Project Area.

Bald Eagle

Bald eagle (*Haliaeetus leucocephalus*) is a federally-listed threatened species (USFWS 1995). Bald eagles occur throughout North America from Alaska to Newfoundland, and from the southern tip of Florida to southern California. In Wyoming, this species builds large nests in the crown of large mature trees such as cottonwoods or pines. Food availability is probably the single most important determining factor for bald eagle distribution and abundance. Fish and waterfowl are the primary sources of food where eagles occur along rivers and lakes. Big game and livestock carrion, as well as larger rodents (e.g., prairie dogs) also can be important dietary components where these resources are available (Ehrlich et al. 1988). This species is an uncommon breeding resident in Wyoming utilizing mixed coniferous and mature cottonwood-riparian areas near large lakes or rivers as nesting habitat (Luce et al. 1999). As reported in the WGFD Annual Completion Report 2000 (Cerovski et al. 2000), there were 97 nesting attempts in the state. This is the highest recorded number of nest attempts since 1978.

Eagles are expected to winter within areas of suitable habitat within the Project Area. Feeding areas, diurnal perches, and night roosts are fundamental elements of bald eagle winter habitats. Although eagles can fly as far as 24 kilometers (15 miles) to and from these elements, they primarily occur where all three elements are available in comparatively close proximity (Swisher 1964). Food availability is probably the single most important factor affecting winter eagle distribution and abundance (Steenhof 1978). Typically, fish and waterfowl are the primary food sources where eagles occur along rivers, lakes, streams, and dams. In Wyoming, the availability of carrion, particularly domestic sheep, is an important winter food source for wintering bald eagles.

This species is a documented breeder and winter resident of suitable habitats within the Project Area (Luce et al. 1999). Known bald eagle nests and winter roosts are distributed throughout the Project Area, as indicated by location data provided by the WGFD. These important areas are typically associated with river drainages or other large bodies of water with suitable trees for nesting and roosting.

Mountain Plover

The mountain plover (*Charadrius montanus*) is proposed for federal listing (USFWS 1999b). The USFWS has 60 days to seek input from three species experts, the public, scientific community, and Federal and State agencies. The USFWS published a 60-day extension to the comment period on April 19, 1999 (USFWS 1999c). In October 2001, the USFWS designated the mountain plover as a proposed threatened species (USFWS 2001d).

This species utilizes high, dry, shortgrass prairie with vegetation typically shorter than four inches tall. Within this habitat, areas of blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*) are most often utilized, as well as areas of

mixed-grass associations dominated by needle-and-thread (*Hesperostipa comata*) and blue grama (Dinsmore 1983).

Nests consist of a small scrape on flat ground in open areas. Most nests are placed on slopes of less than five degrees in areas where vegetation is less than three inches tall in April. More than half of identified nests occurred within 12 inches of old cow manure piles and almost twenty percent were found against old manure piles in similar habitats in Colorado. Nests in similar habitats in Montana (Dinsmore 1983) and other areas (Ehrlich et al. 1988) were nearly always associated with the heavily grazed short-grass vegetation of prairie dog colonies.

Mountain plovers arrive on their breeding grounds in late March with egg-laying beginning in late April. Clutches are hatched by late June and chicks fledge by late July. The fall migration begins in late August and most birds are gone from the breeding grounds by late September.

In Wyoming, this species is a common breeding resident (Luce et al. 1999) and does occur within suitable habitats in the Project Area. Data compiled by the BLM office in Buffalo, Wyoming indicate mountain plover nesting has been documented sporadically throughout the Project Area, including northeastern Converse County, near Gillette, and Sheridan. The Wyoming Natural Diversity Database recently published the results of their 2001 survey efforts in the Powder River Basin of Wyoming (Keinath et al. 2001). During these surveys, nine sightings of mountain plovers were recorded, of which two where within the Project Area. Suitable habitat was identified in the Project Area, but characterized as limited and fragmented.

Boreal Western Toad

The southern population of the boreal Western toad (*Bufo boreas boreas*), occurring in the Medicine Bow Mountains, is listed as a USFWS candidate species and Region 2 of the FS lists it as a sensitive species (USFWS 2001d). This species ranges from southeast Alaska throughout British Columbia and Alberta southward through the northwestern United States. In Wyoming, this species occurs in two distinct populations. The northern population, not listed as a federal candidate species, ranges from mid to higher elevations of Yellowstone and Grand Teton National Parks, and the Bridger-Teton, western Shoshone, and Targhee National Forests. The southern population is restricted to a few isolated areas of the Medicine Bow National Forest. The southern population may be extirpated. In 2000, survey efforts located three individuals and did not observe signs of reproduction at historical breeding locations. Habitat for this species includes moist or wet areas of foothill, montane, and subalpine regions including subalpine meadows, aspen and spruce-fir forests, and all riparian habitats occurring between 8,000 and 11,900 feet elevation (USGS 2001). Adult toads are sometimes found in drier habitats when dispersing (Keinath and Bennet 2000). However, current distributions are not known north of Carbon County, south of the Project Area. This species is not expected to occur within the Project Area.

BLM, Forest Service, and Wyoming Game and Fish Department

Dwarf Shrew

The dwarf shrew (*Sorex nanus*) is listed as a sensitive species by Wyoming BLM and Region 2 of the FS. The WGFD categorizes this species as SSC3. This species is restricted to the Rocky Mountains from Montana to New Mexico and Utah to South Dakota, although this range is not continuous. Wyoming forms part of the core of its range. Suitable for this species is typically alpine and subalpine rockslides, but may also include spruce/fir bogs, coniferous forests, and open woodlands (Fitzgerald et al. 1994). However, records do exist from lower elevation habitats including shortgrass prairie, dry stubble fields, and pinyon-juniper woodlands (Clark and Stromberg 1987). It is known from relatively small, isolated, relict populations in the Medicine Bow and the Bighorn Mountains and in northwest Wyoming (Albany, Carbon, Park, Johnson, and Teton counties) (Welp et al. 2000). Clark and Stromberg (1987) expect that the range includes most of Wyoming, except the basins of northeast Wyoming and the southeastern grasslands. The WGFD characterize the dwarf shrew as a rare resident occurring in southern and western portions of the state (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

Long-eared Myotis

The long-eared myotis (*Myotis evotis*) is listed as a sensitive species by Wyoming BLM and categorized as SSC2 by WGFD. This species occurs throughout the western portion of North America south to Baja California. Wyoming is close to the eastern periphery of its range. Clark and Stromberg (1987) indicated that this species is distributed statewide, with records in Park, Bighorn, Teton, Platte, Fremont, Sublette, Natrona, Sweetwater, Carbon and Laramie counties. In sagebrush steppe habitat, such as Sweetwater County, they are probably limited to small stands of conifers. Preferred habitats include coniferous forests, including ponderosa pine and spruce-fir, forests, sagebrush shrublands, and grasslands (Luce et al. 1999). This species roosts in caves, buildings, and mine tunnels (Clark and Stromberg 1987). This species may occur in suitable habitats within the Project Area.

Fringed Myotis

The fringed myotis (*Myotis thysanodes*) is a BLM and Region 2 FS sensitive species and the WGFD categorizes it as SSC2. The main range of this species extends from British Columbia through western North America to southern Mexico. In Wyoming, this species is found along the eastern edge of the state from the Black Hills to Laramie in Weston, Platte, Albany, Sublette, and Laramie counties (Welp et al 2000). This species is associated with a variety of vegetation community types, including montane meadows, sagebrush shrublands, desert scrub, mixed grass prairies, and woodlands, although it appears to prefer coniferous forests (Fitzgerald et al. 1994). Caves, mines, and buildings are used as day and night roosts for colonies of up to several hundred individuals. This species may occur in suitable habitats within the Project Area.

Townsend's Big-eared Bat

Townsend's big-eared bat (*Corynorhinus townsendii* [*Plecotus townsendii*]) is listed as a sensitive species by Region 2 of the FS and categorized as SSC2 by WGFD. This species is most common throughout the western half of North America and occurs south into central Mexico. Although Wyoming forms part of the core of this main range, it is distributed sparsely throughout the state (Clark and Stromberg 1987). It has been recorded in Converse, Goshen, Platte, Crook, Fremont, Big Horn, Hot Springs, Sweetwater, Washakie, Park, and Johnson counties. Suitable habitats in Wyoming include deciduous forests, dry coniferous forests, sagebrush and other shrublands, shortgrass and mixed grass prairies, and juniper woodlands. This species utilizes caves, buildings and rock outcrops for day and night roosts and hibernation sites (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

Spotted Bat

Spotted bat (*Euderma maculatum*) is listed as a sensitive species by Wyoming BLM and Region 2 of the FS and the WGFD categorizes it as SSC2. This bat occurs in western North America from Mexico to the southern border of British Columbia. Wyoming is on the northeast periphery of its range (Welp et al. 2000). In Wyoming, a single documented occurrence of this species exists from near Byron (Clark and Stromberg 1987). Suitable habitat in Wyoming includes juniper and sagebrush shrublands, short- and mixed-grass prairies (Luce et al. 1999). Roosting sites in rock crevices and cliff complexes are also known to be important (Welp et al. 2000). This species is often described using cliffs over perennial water (Clark and Stromberg 1987). In Wyoming, its range typically excludes the eastern half of the state (Clark and Stromberg 1987). This species is not expected to occur within the Project Area.

White-tailed Prairie Dog

White-tailed prairie dog (*Cynomys leucurus*) is listed as a sensitive species by Wyoming BLM. This species occurs in parts of Colorado, Utah, Wyoming, and Montana. In Wyoming, it occurs in the western half of the state occupying grasslands, shrublands, and desert-grass communities (Clark and Stromberg 1987). In Wyoming, this is a common resident occupying sagebrush shrublands, and short- and mixed-grass prairie throughout much the state (Luce et al. 1999). This species is known to occur in suitable habitats within the Project Area, but specific population and occurrence pattern data are not available.

Water Vole

Water vole (*Microtus richardsoni* [*Arvicola richardsoni*]) is listed as a sensitive species by Wyoming BLM and categorized by WGFD as SSC3. The main range of this species lies north and west of Wyoming in the Pacific Northwest, extending well into Canada. Topographic features such as mountains and valleys act as barriers. In Wyoming, water voles have a highly disjunct, limited geographic range (Welp et al. 2000). Clark and Stromberg (1987) reported this species from Park, Big Horn, Hot Springs, Sublette, Lincoln and Uinta counties, and suggest that they also occur in portions of Sheridan, Washakie, and Johnson counties. Suitable habitats in Wyoming include low gradient streams bordered by overhanging banks in subalpine to alpine meadows or Douglas-fir forests. They also occasionally occur in burrows in alpine grassland. In the Owl Creek Mountains,

voles are found along marshy creeks at 2800 to 3000 meters in aspen communities (Welp et al. 2000). This species is not expected to occur within the Project Area.

Wolverine

Wolverine (*Gulo gulo* [*Gulo luscus*]) is listed as a sensitive species by Region 2 of the FS and categorized as SSC3 by the WGFD. Distribution is boreo-arctic with southward extensions along major mountain ranges. Wyoming is on the southern periphery of the range. Documented occurrences in Wyoming exist for Fremont, Sheridan, Lincoln, Park, Sublette, and Teton counties and the species is suspected in Big Horn County. In summer and fall, wolverines are found in late-successional mixed subalpine fir, spruce, and lodgepole pine forests with closed canopies. Areas above timberline are used for denning, travel, and scavenging (Wyoming Game and Fish Department 1997). Wolverines descend to lower elevations in winter, perhaps to riparian areas (Welp, et al. 2000). This species is not expected to occur within the Project Area due to its limited range within the state.

Swift Fox

In January of 2001, the USFWS did not support listing this species as threatened under the Endangered Species Act (USFWS 2001a) based on new biological information. The swift fox (*Vulpes velox*) is currently listed as a sensitive species by Region 2 of the FS and categorized by WGFD as SSC3. The swift fox is found in short- and mixed-grass prairie habitats. It appears to prefer flat to gently rolling terrain. The swift fox preys on small rodents, rabbits, and birds. Pups emerge from the den in June. Dens are generally located along slopes or ridges that offer good views of the surrounding area (Fitzgerald et al. 1994). Where they are abundant, they occur at a density of one pair per 1,200 to 2,000 acres. Individuals may roam over 2,000 to 2,500 acres during a night of hunting (Clark and Stromberg 1987). In Wyoming, this species is considered a common resident utilizing grasslands in the eastern plains, agricultural areas, irrigated native meadows, and the banks of roads and railroads (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

American Marten

American marten (*Martes americana*) is listed as a sensitive species by Region 2 of the FS. Marten have a boreal distribution with southern extensions along major mountain ranges. Isolated populations occur on mountain ranges in Montana, and in the Bighorn Mountains of Wyoming. This species has been recorded in Park, Teton, Lincoln, Fremont, and Carbon counties, and is also known to occur in portions of Uinta, Sublette, Hot Springs, Big Horn, Sheridan, Washakie, Johnson and Albany counties (Welp et al. 2000). Currently, the Wyoming Natural Diversity Database tracks martens only in the Bighorn Mountains, which comprise a state endemic population restricted to Big Horn, Johnson, Hot Springs, Washakie, and Sheridan counties. Because it has been isolated from adjacent populations for possibly as long as 8,000 years, the Bighorn Mountains population is of significant management concern. Marten are specialized for a narrow range of habitats. They require late-seral stands of mesic conifers, especially those with a complex understory structure of more than 30 percent cover (Clark et al. 1989b; Buskirk and Powell 1994). Spruce-fir stands are preferred, but marten will also use stands of lodgepole and limber pine, especially if near-ground

structures are abundant. They are rare or absent in ponderosa and pinyon pine habitats (Buskirk and Powell 1994). This species is not expected to occur within the Project Area.

Least Weasel

Least weasel (*Mustela nivalis* [*Mustela rixosa*]) is listed as a sensitive species by Region 2 of the FS. The main distribution of this species is in the upper Midwest of the U.S. and southern Canada. Clark and Stromberg (1987) suggest that the Wyoming population may be a disjunct relict about 200 miles from the nearest known contiguous population in Nebraska and South Dakota. Sagebrush shrublands occur throughout the entire Project Area, with the Bighorn Mountains and associated foothills as the only exceptions. Although common in the southern portions of the Project Area, larger more contiguous tracts of sagebrush occur in the northeastern, central, and eastern portions of the Project Area. Typical habitats include gentle rolling ridges dominated by sagebrush and grasses with sporadic riparian corridors of willow and cottonwood (Clark and Stromberg 1987). This species may occur in suitable habitats within the Project Area.

American Peregrine Falcon

American peregrine falcon (*Falco peregrinus anatum*) has been recently delisted as a federally protected species (USFWS 1999a). The WGFD categorizes this species as SSC3. This species occurs across North America utilizing a variety of habitats. The peregrine falcon is typically associated with open country near rivers, marshes, and coasts. Cliffs are preferred nesting substrate; however, tall man-made structures may be used (Spahr et al. 1991). Peregrines typically prey on birds such as waterfowl, shorebirds, grouse, and pigeons. In Wyoming, this species is a rare resident with most breeding records from the western portion of the state (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

American Bittern

American bittern (*Botaurus lentiginosus*) is listed as a sensitive species by Region 2 of the FS and categorized as SSC3 by WGFD. This species breeds from south-central British Columbia to Newfoundland. In the United States, this species nests in all western and northern states. The American bittern rarely wanders far from marshy, swampy areas (Kingery 1998). This species typically feeds on fish, aquatic invertebrates, and insects. In Wyoming, this species is an uncommon summer resident (Luce et al. 1999). This species has been observed throughout much of the state, including the Project Area (Luce et al. 1999).

White-faced Ibis

White-faced ibis (*Plegadis chihi*) is listed as a sensitive species by Wyoming BLM and Region 2 of the FS, and categorized as SSC3 by WGFD. This species nests from central Mexico to Louisiana and Texas and through the Great Basin, with isolated colonies in Alberta, New Mexico, California, Montana, North Dakota, Iowa, and Kansas. Preferred nesting habitat includes tall emergent vegetation such as bulrushes and cattails growing as islands surrounded by water deeper than 18 inches. Feeding habitats may include wet hay meadows and flooded agricultural croplands, as well as marshes and shallow water ponds, lakes, and reser-

voirs (Kingery 1998). This species primarily feeds on aquatic invertebrates and insects. In Wyoming, this species is an uncommon summer resident (Luce et al.1999). This species has been observed throughout much of the state, including the Project Area (Luce et al. 1999).

Trumpeter Swan

Trumpeter Swan (*Cygnus buccinator*) is listed as a sensitive species by the Wyoming BLM. This species breeds in southern Alaska, northern British Columbia, western Alberta, Oregon, Idaho, Montana, and Wyoming. Following habitat destruction and over-hunting, this species was close to extinction. Careful management and reintroduction practices have helped return population numbers to several thousand individuals (Udvardy 1977). Suitable habitats for this species include lakes and ponds with developed aquatic vegetation for feeding and nesting materials (Terres 1980). Trumpeter swans typically feed on aquatic vegetation, aquatic invertebrates, and insects. This species has been observed throughout the state, including the Project Area, but there was no reported evidence of nesting (Luce et al. 1999).

Northern Goshawk

Northern goshawk (*Accipiter gentiles*) is listed as a sensitive species by Wyoming BLM and Regions 2 and 4 of the FS and categorized as SSC4 by the WGFD. This species occurs from Alaska through the Rocky Mountains to New Mexico and in the mountains and forests of Washington, Oregon, and interior California (Udvardy 1977). This raptor typically prey on habitats, squirrels, ducks, and other birds. Northern goshawks nest in a variety of habitats including conifer and aspen forests, and occasionally cottonwood trees (Kingery 1998). This species is a documented breeding resident of Wyoming and the Project Area (Luce et al. 1999).

Merlin

Merlin (*Falco columbarius*) is listed as a sensitive species by Region 2 of the FS and categorized as SSC3 by WGFD. This species nests in boreal forests below treeline from coast to coast and along the western mountains south to Oregon, Idaho, and Montana. It winters in southern latitudes from the southern United States to South America (Udvardy 1977). In Wyoming, this species is an uncommon resident occurring in a diversity of habitats below 8,500 feet, including open country and coniferous forests (Luce et al. 1999). Merlin typically rely upon locally abundant small bird populations, but will also prey on toads, reptiles, and mammals (Welp et al. 2000). This species is a documented breeder throughout much of the state, including the Project Area (Luce et al. 1999).

Upland Sandpiper

Upland sandpiper (*Bartramia longicauda*) is listed as a sensitive species by Region 2 of the FS and categorized as SSC4 by WGFD. This species nests from Alaska to Maine, south to northwestern Oklahoma and the mid-Atlantic states. The upland sandpiper nests in mid- to tall-grasslands and croplands, utilizing the tall vegetation to hide the nest (Kingery 1998). In Wyoming, this species nests in grasslands in the eastern portion of the state (Luce et al. 1999). Upland sandpipers typically feed on insects, terrestrial invertebrates, and seeds. This species is

an uncommon breeding resident occurring in suitable habitats throughout much of eastern Wyoming, including the Project Area (Luce et al. 1999).

Long-billed Curlew

Long-billed curlew (*Numenius americanus*) is listed as a sensitive species by Wyoming BLM and Region 2 FS and categorized as SSC3 by WGFD. This species occurs from southern British Columbia to Manitoba, southeast to Wisconsin, Illinois, and Kansas, south to northern California and northern Texas. The long-billed curlew nests on shortgrass prairies and feeds on insects and aquatic invertebrates in salt marshes, mud flats, and beaches (Udvardy 1977). In Wyoming, suitable habitat may include sagebrush shrublands, wet meadows, irrigated meadows, and agricultural areas (Luce et al. 1999). This species is an uncommon breeding resident occurring in suitable habitats throughout much of eastern Wyoming, including the Project Area (Luce et al. 1999).

Yellow-billed Cuckoo

Yellow-billed cuckoo (*Coccyzus americanus*) is listed as a sensitive species by Wyoming BLM and Region 2 of the FS, and categorized by WGFD as SSC2. This species once ranged throughout the United States, southern Canada, and Mexico. The range of the western subspecies has been dramatically reduced and mostly limited to California and Arizona (Kingery 1998). In Wyoming, this species is an uncommon summer resident occupying cottonwood riparian areas below 7,000 feet and urban areas. Typical prey include insects, especially hairy caterpillars. It has been recorded in most areas of the state except for the montane regions (Luce et al. 1999). This species may utilize suitable habitats within the Project Area.

Burrowing Owl

Burrowing owl (*Athene cunicularia*) is listed as a sensitive species by Region 2 of the FS and categorized as SSC4 by WGFD. This species occurs from south-central British Columbia eastward to southern Saskatchewan and south through most of the western United States. Burrowing owls primarily nest in rodent burrows, particularly prairie dog burrows, in grasslands, shrublands, deserts, and grassy urban settings (Kingery 1998). In Wyoming, this species uses grasslands, sagebrush and other shrublands, and agricultural areas. Burrowing owls typically feed on insects, rodents, lizards, and small birds. This species is a confirmed breeder throughout much of the state (Luce et al. 1999). This species is known to occur in suitable habitats within the Project Area.

Lewis' Woodpecker

Lewis' woodpecker (*Melanerpes lewis*) is listed as a sensitive species by Region 2 of the FS and categorized as SSC3 by the WGFD. This species occurs from southern British Columbia and Alberta south to northern Arizona and south-central California. Suitable habitat for this species includes pine-oak woodlands, oak or cottonwood groves in grassland and ponderosa pine forests (Udvardy 1977). In Wyoming, this species principally occurs in open ponderosa and lodgepole pine forests and savannah and recently burned forests with abundant snags or stumps, mainly below 9,000 feet elevation. It also uses aspen, mixed pine-juniper, and cottonwood riparian habitats. Mated pairs may return to the same

nest site in successive years (Welp et al. 2000). This woodpecker is opportunistic foraging on locally and temporarily abundant insect populations during spring and summer and on fruits during fall and winter (e.g., ants, beetles, flies, grasshoppers, and tent caterpillars). It is known to occur throughout most of the state except for higher elevation mountain regions (Luce et al. 1999). This species may utilize suitable habitats within the Project Area.

Three-toed Woodpecker

Three-toed woodpecker (*Picoides tridactylus*) is listed as a sensitive species by Region 2 of the FS. This species occurs from Alaska across northern Canada to Newfoundland, south along the western mountains to the Oregon Cascade Mountains in the west and east to Arizona and New Mexico. Coniferous forests are suitable habitats, particularly forests near recent burns (Udvardy 1977). In Wyoming, this species utilizes lodgepole pine, Douglas fir, and Englemann spruce-subalpine fir. This species typically feeds on insects, wood-boring beetles and tree sap. This woodpecker has been observed in most regions of the state except for the northeastern grasslands (Luce et al. 1999). This species may utilize suitable habitats within the Project Area.

Loggerhead Shrike

Loggerhead shrike (*Lanius ludovicianus*) is listed as a sensitive species by Wyoming BLM. This species occurs from North America south of the coniferous forest region into Mexico (Udvardy 1977). The loggerhead shrike is typically associated with open vegetation types, including agricultural areas, sagebrush shrublands, desert scrub, pinyon-juniper woodlands, and montane meadows (Johnsgard 1986). In Wyoming, this species is a common summer resident utilizing pine-juniper, woodlands short- and mixed-grass prairies, and shrublands. Loggerhead shrike typically feed on grasshoppers and crickets as well as other insects, mice, and small birds. This species is known to breed throughout the state (Luce et al. 1999) and is known to occur in suitable habitats within the Project Area.

Golden-crowned Kinglet

The golden-crowned kinglet (*Rugulus satrapa*) is listed as a sensitive species by Region 2 of the FS. This species occurs in the northern United States and Canada occupying dense coniferous forests (Kingery 1998). In the western mountain chains, this species utilizes the Douglas fir and subalpine fir zones (Udvardy 1977). In Wyoming, this species occupies coniferous and aspen-conifer forests of western and central Wyoming (Luce et al. 1999). This species typically feeds on insects, tree sap, fruits and seeds. The golden-crowned kinglet is an uncommon resident of the northeastern portion of Wyoming (Luce et al. 1999) and may utilize suitable habitats within the Project Area.

Pygmy Nuthatch

The pygmy nuthatch (*Sitta pygmaea*) is listed as a sensitive species by Region 2 of the FS and categorized as SSC4 by WGFD. Distribution of this species seems to be related to the occurrence of ponderosa pine. This species is widespread from southern British Columbia eastward through the Black Hills, and south to Baja California and mainland Mexico (Udvardy 1977). In Wyoming, it occurs at

scattered locations statewide during the winter. During the breeding season, it is associated with mountain habitats in coniferous forests at the periphery of the state. This species has been observed breeding in the Bighorn and Medicine Bow National Forests and in most other coniferous habitats within the state. Ponderosa pine woodlands in the Black Hills and in the Douglas / Guernsey regions have the best potential to support large groups of breeders (Welp et al. 2000). Pygmy nuthatches typically feed on insects and conifer seeds. This species may utilize suitable habitats within the Project Area.

Sage Thrasher

The sage thrasher (*Oreoscoptes montanus*) is listed as a sensitive species by the Wyoming BLM. This species occurs from south-central British Columbia to southern Nevada, Utah, through Texas and Oklahoma, and in the San Joaquin Valley of California (Udvardy 1977). In Wyoming, this species is a common summer resident breeding in sagebrush shrublands throughout the state (Luce et al. 1999). Sage thrashers typically feed on insects and some fruit. This species may utilize suitable habitats within the Project Area.

Sage Sparrow

The sage sparrow (*Amphispiza belli*) is listed as a sensitive species by the Wyoming BLM. This species occurs from Washington south to Baja California, and throughout the Great Basin (Udvardy 1977). The sage sparrow is a common summer resident in the Wyoming grasslands and shrublands typically feeding on insects and seeds (Luce et al. 1999). This species may utilize suitable habitats within the Project Area.

Baird's Sparrow

The Baird's sparrow (*Ammodramus bairdii*) is listed as a sensitive species by the Wyoming BLM. This species ranges from Alberta, Saskatchewan, and Manitoba and Montana to South Dakota (Udvardy 1977). In Wyoming, this species is an uncommon summer resident using shortgrass prairie habitats (Luce et al. 1999). Typical diet for this species consists of seed and insects. This species may utilize suitable habitats within the Project Area.

Brewer's Sparrow

The Brewer's sparrow (*Spizella breweri*) is listed as a sensitive species by the Wyoming BLM. This species ranges from British Columbia east to Saskatchewan, south to New Mexico, Arizona, and southern California (Udvardy 1977). In Wyoming, this species is a common summer resident occupying sagebrush shrubland, and other shrubland habitats throughout the state (Luce et al. 1999). Brewer's sparrow typically feed on insects and seeds. This species may utilize suitable habitats within the Project Area.

Northern Leopard Frog

The northern leopard frog (*Rana pipiens*) is listed as a sensitive species by the Wyoming BLM and Region 2 of the FS. This species is found throughout much of boreal Canada, south through the upper mid-west and central plains states, westward into Idaho, Nevada, northern Arizona, and New Mexico (Stebbins 1985). In Wyoming, this species occurs in cattail marshes and beaver ponds from

the plains to montane conditions as high as 9,000 feet elevation (Luce et al. 1999). Adult leopard frogs typically feed on insects, invertebrates, and small vertebrates including tadpoles, snakes, and fish. This species may utilize suitable habitats within the Project Area.

Columbia Spotted Frog

The Columbia spotted frog (*Rana luteiventris* [*Rana pretiosa*]) is listed as a sensitive species by Wyoming BLM and Region 2 of the FS. This species occurs through much of British Columbia and in Washington, Oregon, Idaho, Montana, Nevada, Utah, and Wyoming (Stebbins 1985). Wyoming is on the eastern edge of the range, where it is known from Park, Teton, Lincoln, Fremont, Sheridan, and Sublette counties. The primary population is in the northwest part of the state, where it is contiguous with populations in Idaho and Montana (Welp et al. 2000). A glacial disjunct population occurs in the Bighorn Mountains about 100 miles to the east of the primary, contiguous population. It is confined to the headwaters of the South Tongue River drainage and its tributaries in Sheridan County (Garber 1994). In Wyoming, suitable habitats can be found in foothills and montane zones usually in the vicinity of permanent water such as ponds, sloughs, small streams, and beaver ponds. This species may avoid areas with warm stagnant water and dense cattails. It breeds in old oxbow ponds in which fish are absent, with emergent sedges in wet meadows at the edge of lodgepole pine forests (Garber 1994). Adult spotted frogs typically feed on insects, invertebrates and small vertebrates including tadpoles and other frogs. This species may utilize suitable habitats within the Project Area.

Wood Frog

The wood frog (*Rana sylvatica*) is listed as a sensitive species by Region 2 of the FS. This species ranges throughout much of Canada, through the Midwest and Atlantic states southward to Tennessee. Isolated populations occur in Wyoming, Colorado, Missouri, and Arkansas (Stebbins 1985). In FS Region 2, wood frogs occur only on the Medicine Bow/Routt and Bighorn National Forests (Welp et al. 2000). Both populations are likely glacial relicts. The Medicine Bow population occurs in the Medicine Bow Mountains in Albany and Carbon counties, and extends into northern Colorado. The Bighorn population occurs 225 miles to the north in the Dome Lake area of the central Bighorn Mountains in Bighorn, Johnson, and Sheridan counties (Welp et al. 2000). In Wyoming, this species is typically associated with ponds, slow-moving streams, and wet grass/sedge meadows that do not contain fish (Baxter and Stone 1985). It is also found in glacial kettle ponds within coniferous forest and in beaver ponds on first order streams (Garber 1994). The wood frog breeds on northern edges of small shallow ponds with emergent graminoids and willows at high elevations, usually above 8,000 feet elevation. This frog's diet mainly consists of invertebrates. This species is not expected to occur within the Project Area.

Milk Snake

The milk snake (*Lampropeltis triangulum*) is listed as a sensitive species by Region 2 of the FS. This western subspecies occurs in the western and central states from Montana southward to northern Texas, including isolated populations in Utah, Colorado, and New Mexico (Stebbins 1985). In Wyoming, this species is also known from scattered records in the Bighorn Basin, the east slope of the

Bighorn Range, and the Laramie Range in Albany, Big Horn, Washakie, Hot Springs, Platte and Goshen counties. It is also suspected to occur in Sheridan, Campbell, Crook, Weston, Niobrara, Converse and Natrona counties. In Wyoming, this species is found in diverse habitats from lowlands to mountains, grasslands to open forests, and wilderness to suburban. It often occurs in plains and foothills below 5,900 feet elevation, but is almost never found in the shortgrass communities of the plains (Welp et al. 2000). Diet of this snake typically includes small mammals, birds, lizards, snakes, and bird eggs. This species may occur in suitable habitats within the Project Area.

Grasshopper Sparrow

The grasshopper sparrow (*Ammodramus savannarum*) is categorized as an SSC4 by the WGFD. This species ranges from coast to coast south of the of boreal forest belt and mainly north of the southwestern deserts (Udvardy 1977). In Wyoming, this species is a common summer resident utilizing a variety of non-montane habitats including sagebrush shrublands, short- and mixed-grass prairies, wet meadows, and agricultural areas (Luce et al. 1999). This sparrow typically feeds on insects and seeds. This species may utilize suitable habitats within the Project Area.

Special-Status Aquatic Wildlife Species

Sturgeon Chub

In April of 2001, the USFWS announced the listing of the sturgeon chub (*Macrhybopsis gelida*) as endangered but was not warranted due to recent re-evaluations of distribution and population numbers (USFWS 2001b). Historically, the sturgeon chub was found throughout the Missouri River basin from the Yellowstone River in Montana and the Powder River in Wyoming, downstream through the Missouri River and into the middle and lower Mississippi River to Louisiana. In Wyoming, this species is restricted to the Lower Bighorn and Powder Rivers. Preferred habitat is above gravel bottoms within large, turbid, fast-moving rivers. Sturgeon chub are most abundant in gravel riffles, but sometimes are found in sandy bottom pools containing some gravel. Sturgeon chub usually occur in less than three feet of water, and eat primarily bottom-dwelling invertebrates. Chub spawn in late spring to midsummer when water temperatures are between 65 and 72°F. Spawning occurs within shallow rapids over gravel and rock. The Powder River in Wyoming supports the largest known reproducing population of sturgeon chub (Gerard 1999). This species has been documented in the Powder River from below Crazy Woman Creek up to the confluence with Salt Creek. Sturgeon chub were also documented to occur in Crazy Woman Creek above its confluence with the Powder River (Patton 1997) and, therefore, is known to occur within the Project Area (Table 3–46).

Yellowstone Cutthroat Trout

In February of 2001, the USFWS announced that the petition to list the Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) failed to present substantial information that listing of this species was warranted (USFWS 2001c). This species is listed as a sensitive species by the Wyoming BLM and Region 2 of the FS.

Streams immediately below and above Yellowstone Lake are the global stronghold for this taxon. It is native to the Yellowstone River drainage downstream to the Tongue River, including the Big Horn/Wind and Clarks Fork River drainages (Welp et al. 2000). This species is also found west of the Continental Divide in the Snake River drainage below Palisades Reservoir in Idaho and in Pacific Creek and other tributaries of the Snake River above the Gros Ventre River. It has been introduced to waters east of the Continental Divide (Baxter and Stone 1995). The Yellowstone cutthroat trout has been recorded from Teton, Park, Sheridan, Johnson, and Big Horn counties (Welp et al. 2000). Suitable habitats include coldwater rivers, creeks, beaver ponds, and large lakes. Optimum water temperature generally may be 4.5 to 15.5°C, but tolerance of much warmer temperatures probably occurred historically in larger rivers. Warm-water populations occur in some geothermally-heated streams (Gresswell 1995), including some at least 81°F in Yellowstone National Park (Clark et al. 1989b). This species may occur in suitable aquatic habitats within the Project Area (Table 3–46).

Cultural Resources

Regional Characterization

The Project Area is located in the Powder River Basin of northeast Wyoming and includes all of Campbell County, and large portions of Converse, Johnson, and Sheridan counties. The principal current land uses are ranching and energy development. For the purposes of analysis, this large area is subdivided into 18 watersheds. Current land use is dominated by ranches that raise cattle, sheep, and smaller numbers of bison, and by mineral and energy development. Coal mines are largest and most numerous in the eastern edge of the Project Area in the Fort Union Formation. In the past, the Project Area supported large herds of bison. Prior to Euroamerican settlement, the seasonal to irregular availability of water and general lack of sheltered areas discouraged large, permanent settlements.

Most of the central portion of the Project Area is underlain by lower Eocene sandstones, claystones, and coal beds of the Wasatch Formation. Smaller but locally extensive areas around the edges of the Project Area are underlain by Paleocene sandstones, shales, and coal beds of the Lebo, Tongue River, and Tullock members of the Fort Union Formation. Little high quality raw material for prehistoric stone tool manufacture occurs in these deposits. Local raw materials for stone tools are dominated by high quality klinkers produced through the metamorphosis of claystones by burning coal seams. Exotic raw materials from the Black Hills, the Hartville Uplift, the Bighorn Mountains, or more distant sources stand out from drab local materials.

Cultural Context

Cultural resource sites are defined as discrete locations of past human activity, which can include artifacts, structures, works of art, landscape modifications, and natural features or resources important to history or cultural tradition. These sites can include extensive cultural landscapes, such as farm or ranch landscapes, lin-

ear landscapes, such as historic trails with associated towns, forts and way stations, or railroad landscapes, and traditional use areas. In this document important sites (sites that will require additional consideration) include both listed and eligible sites (those sites that are listed on, determined eligible for, or recommended eligible for the National Register of Historic Places under the Criteria for Evaluation (36 CFR § 60.4) or National Landmarks) and sites that have not been evaluated. For the purposes of this analysis, unevaluated sites are considered potentially eligible, because they have not been determined to be not eligible, and therefore require avoidance or evaluative investigations.

Prehistoric

All recognized prehistoric cultural periods, from Clovis through Protohistoric (about 11,500 to 200 years ago), are represented to some extent in the project area. The broad prehistoric chronological periods used in this region are:

- Paleoindian Period (11,500 to 8,000 years ago)
- Early Plains Archaic (8,000 to 5,000 years ago)
- Middle Plains Archaic (5,000 to 2,500 years ago)
- Late Plains Archaic (2,500 to 1,500 years ago)
- Late Prehistoric and Protohistoric (1,500 to 200 years ago)

Approximately 10 percent of the Project Area has been investigated, primarily in the eastern portion of the Basin. In this small sample of the project area the earliest prehistoric cultural periods, Paleoindian through Early Plains Archaic, are represented by only a small number of sites. Archaic and later prehistoric period sites (Archaic to Protohistoric) are represented in increasing numbers as a result of higher populations through time and better preservation of more recent sites (Table 3–48).

Important prehistoric site types in the region include artifact scatters, stone circle sites, kill sites and faunal processing sites, rock alignments and cairns, and stone material procurement areas. The following prehistoric site types are used in the tabulation of known sites from a files search for the Project Area conducted through the Wyoming Cultural Records Office in Laramie.

Artifact Scatters – Artifact Scatters are predominantly scatters of stone tools and stone tool-making debris in this region, but also include ground stone, ceramics, and composite artifact scatters. These sites are important because they are often the only remnants indicating the presence of human activity. Artifact Scatters may provide information on chronology, subsistence, technology, settlement patterns, and resource choices, and help to understand past lifeways.

Camp – Camps are predominantly sites with artifact scatters and features or a range of artifact types that indicate habitation of the area. Camp includes sites that are listed in the files search as open camp, habitation sites, or artifacts and features. These sites are more often field evaluated as eligible than artifact scatters. These sites are important because they have the potential to yield information that can inform us on issues of settlement, subsistence, technology, chronology, and social organization by various prehistoric peoples. Camps may contain concentrations of associated tools and materials known as activity areas, hearths,

Table 3–48 Tally of Prehistoric Components by Sub-watershed

Sub –watershed	Paleo-indian	General Archaic	Early Archaic	Middle Archaic	Late Archaic	Late Pre-historic	Proto-historic	Total	Total (per-cent)
Upper Tongue River	2	2	2	5	8	20	4	43	3.6
Middle Fork Powder River	9	5	4	20	32	52	1	123	10.2
North Fork Powder River						1		1	.1
Upper Powder River	4	11	2	23	31	75	1	147	12.2
South Fork Powder River					2	3		5	.4
Salt Creek				1	1			2	.2
Crazy Woman Creek	1				8	6	2	17	1.4
Clear Creek	4			2	3	8		17	1.4
Middle Powder River	1	2		3	7	13		26	2.1
Little Powder River	9	10	5	21	51	96	12	204	16.9
Antelope Creek	11	5	18	25	49	86	4	198	16.4
Upper Cheyenne River	9	15	4	23	47	70	4	172	14.2
Total	59	66	40	157	299	545	42	1,208	100
Total (percent)	4.8	5.5	3.3	13.0	24.8	45.1	3.5	100	

Note: Data were available for Campbell, Johnson, and Sheridan counties only. Some sub-watersheds are not listed and others have only minimal data.

storage pits, or other clusters of materials that represent discrete episodes of human activity.

Multi-Component – Multi-component sites are predominantly artifact scatters and camps that contain evidence of use by different cultural groups or by the same group over different periods of time. These sites include diagnostic artifacts and potential for buried remains and are often considered eligible. These sites are important because they provide evidence of settlement and use of the land by a specific cultural group or for a specific time. Multi-component sites may provide information on the migrations of people or technology and help inform us on cultural use of the landscape.

Habitation Features – Habitation features are predominantly stone circle sites in this region, but also include open architecture, structures, lodges, and rockshelters. These sites are important because they are habitation sites that can provide evidence of the range of habitation structural types and preferences and may provide information on settlement patterns, seasonal use of the area, social organization, and past lifeways.

Rock Features – Rock features are predominantly cairns, hunting blinds, and rock alignments but can include any non-habitation rock feature such as a medicine wheel. These sites are important because they provide information on the variety of site types that are possible in the area. These sites may provide information on ceremonial uses in the area, subsistence, territorial markers, and cultural use of the landscape.

Bone – Bone sites are marked by the predominance of animal bone and include bone scatters, kill sites, and butchering sites. These sites are often encoded as eligible. In addition to animal bone, they frequently contain a variety of stone tools, some of which may be time diagnostic. They may also contain hearth or storage features which can yield dateable carbon and other organic materials that can yield important information about the age of the site, the season the site was used, plants that were used, or butchering and processing techniques. They are important because they may inform us on technology, subsistence, and social structure for various prehistoric peoples for identifiable temporal periods

Rock Art – Rock art includes pictographs (painted images) and petroglyphs (images that are carved, ground, incised or pecked into the rock surface) that depict iconography on stone surfaces. These sites are important because they depict iconography of prehistoric people and may provide information on ceremony or subsistence related topics. Many portions of the Project Area do not contain suitable rock surfaces for the production or preservation of rock art.

Lithic Source – Lithic source is location used for acquisition of stone suitable for chipped stone tool manufacture. These locations may be areas of bedrock outcrops containing usable stone, or may be areas where pebbles, cobbles, or boulders of raw material have been redeposited by past geological processes. These sites are important because they may inform us on resource choices and technology of prehistoric peoples. Some materials that were preferred for their appearance or the quality of tools that could be made from them may be found quite far form their sources. The distribution of culturally modified materials away from

lithic source areas can provide important information on the movement or interaction of cultural groups over time.

Feature Only – The category Feature Only is dominated by hearth features that are found as isolated cultural remains but can include any non-architectural feature not in association with artifact scatters. These sites are important because they can provide chronological information and special use or temporary use areas for specific activities. This may provide information on resource choices and cultural use of the landscape.

Human Remains – Human remains are the osteological remains of the prehistoric inhabitants usually found as an internment. Human remains are important for many reasons. For anthropologists they can help provide information on the belief systems and social structures of past people. In addition, they are the remains of the people who once occupied the area and may provide information on ancestry, migrations, health, and basic biological information such as age at death, sex, and stature.

Prehistoric Cultural Landscapes -- Any setting that was used frequently or over a prolonged period of time by one or more cultural groups has the potential to be considered a cultural landscape. A cultural landscape is "a geographic area (including both cultural and natural resources and the wildlife or domestic animals therein), associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Birnbaum 1996:4). Vernacular landscapes encompass cultural materials, cultural features, intentional or casual modifications to the landscape, and resources or physiographic features that made that landscape culturally important. Consequently an eligible landscape cannot be avoided and protected simply by avoiding cultural objects, features and structures. The entire location and setting must be considered in terms of the historic character, that is the sum of all visual aspects, features, materials, spaces associated with the historic context of the landscape.

Prehistoric site densities can vary from extremely high in some settings, such as certain ridgetops and areas near larger, more reliable drainages, to nonexistent in other settings. The factors affecting these differences in density are not always readily apparent. Sites are areas where the evidence of one or more episodes of past human activity is visible on the landscape. If a location is used by a large number of people, or repeatedly over a long period of time, lost or discarded cultural materials will accumulate and sediments may also be altered by the incorporation of organic materials. If the landform remains stable over time and is not degraded, deeply buried, or mechanically disturbed, the site will remain visible. Site density, that is the number of sites found in a given unit area, will be influenced by the size and number of groups that used the area and the extent or density of sought after resources. High site densities are often associated with locations that have a predictable abundance of particular resources, locations that have a moderate abundance of several distinct resources, or locations that are strategically located with access to several resource zones. Another factor that is frequently noted in site location is proximity to a reliable source of water. Other factors may be responses to seasonal conditions, such as winter camps with minimal snow accumulation that are sheltered from the wind, or summer camps on higher benches away from swarming bugs.

In the Protohistoric and early historic periods the Project area was the territory of numerous tribes including, the Arikara, Crow, Lakota/Dakota, Arapaho, Kiowa, Comanche, Blackfeet, Cheyenne, and Shoshone. The region was a crossroads for many different Plains tribes, some of which used the area on a regular basis, and others, which entered the region occasionally for particular resources. Numerous confrontations occurred in the area among tribal groups, and with Euroamerican settlers and emigrants passing through to other areas.

Historic

The historic period of the area falls within the last two hundred years, and begins with transient, widely separated incursions by explorers and fur traders. Exploration and the establishment of the Rocky Mountain Fur Trade intensified Euroamerican presence in the Powder River Basin in the early 1800s. Early market trade in the region was centered on bulk items such as furs and depended on river transport. Trading forts at Fort William (later known as Fort Laramie) and several major forts along the Yellowstone River were major centers with a dynamic system of smaller forts and periodic rendezvous. European and Indian trappers and traders ranged through the mountains and basin for furs and returned to the trading forts to exchange marketable goods for supplies. First hand accounts indicate that a significant part of many trappers' income was also spent on gaming and whiskey. For many years these trading forts were major focal points of Euroamerican activities in the region.

After the decline of the fur trade in the late 1830s several of the major emigrant trails of the 1840s and 1850s passed the south end of the Project Area along the North Platte corridor. Fort Laramie served as a major supply point along the Oregon, California, and Mormon trails and was a focal point for overland emigrants. Portions of the emigrant trails in the Fort Laramie region were notorious for predations by Pawnee and Lakota bands. In 1845 Fort Laramie was still controlled by the American Fur Company, but Colonel Stephen Kearney left a detachment of about 100 men to provide protection for emigrants stopping at the fort. This famous fur-trading post was purchased by the US government in 1849 to become the second regular military installation along the Oregon and California trails, the first having been Fort Kearny in Kansas. In 1851 Fort Laramie was the site of an historic general treaty with the plains tribes. The Fort Laramie Treaty Council of 1851 was the greatest gathering of plains tribes ever and though it was considered a success, it did not completely eliminate hostilities. Fort Laramie provided many important services to the overland immigrant such as protection, a place to stay in winter, health care, and mail. (Unruh 1992:156).

With the emergence of the Montana gold fields in the 1860s, trails were established through the Project Area. The mid to late 1860s were intense years in Wyoming, and in the Powder River Basin in particular. The first variant of the Bozeman Trail was tried in 1863 by a group of 46 wagons. This first wagon train was turned back by Cheyenne and Lakota near present-day Buffalo. Three wagon trains followed the route in 1864. One of the latter wagon trains, often called the Townsend Train, was attacked by Cheyenne near the Powder River, and several emigrants were killed. There were several competing expeditions from 1864 through 1866 to identify a better route for a trail to the Montana gold fields and many gold seekers set out on their own without an established trail. Among the

competing expeditions were the Sawyer expeditions of 1864, and 1865-1866, which attempted to establish a trail through the Powder River Basin south of Gillette and through Sheridan. Sites associated with these expeditions have been documented in Campbell and Sheridan counties. The expeditions were harassed by groups of Arapaho, Cheyenne, and Lakota, and on several occasions were pinned down for days or weeks. It became a customary practice in this region for several years to circle the wagons at the end of the day, dig rifle pits around the perimeter, and post pickets around the wagons and livestock. No viable trail was established across the middle of the basin due to Indian predations, unreliable water sources, and difficult terrain.

The Bozeman route along the western edge of the basin proved more viable. There were many documented confrontations between native tribes and Euroamericans along the Bozeman Trail. Among the more famous were the Wagon Box Fight, the Fetterman Massacre, and the Crazy Woman Battle. The area around the crossing at Crazy Woman Creek was the site of many other skirmishes as well. Despite sustained problems with the native groups, the Bozeman Trail was used sporadically, and military forts were established to protect the wagon trains, including Fort Reno and Fort Phil Kearney. In the Fort Laramie Treaty of 1868 the tribes were granted control of the Powder River Basin, troops were withdrawn from the forts, and the trail was closed for several years.

Although east of the Project Area, the discovery of gold in the Black Hills by Lieutenant Colonel Custer in 1874 stimulated an influx of gold seekers and settlers into the Black Hills and Powder River Basin. The influx into the sacred Black Hills enraged the tribes. The tribes refused to negotiate or come into the agencies, and the United States launched major campaigns against the "hostiles" in 1876, with the troops out of Fort Fetterman, near present Douglas, following the Bozeman Trail north. With the major Plains Indian campaigns of the late 1870s, the tribes were driven out of the Powder River Basin and the Bozeman Trail reopened. The arrival of the railroad and the establishment of Cheyenne in 1867 had made the Powder River Basin more accessible, and with the removal of the Indian threat, settlers began to filter in. In 1878 and 1879 mail and stage service was established roughly following the Bozeman Trail. Other historic corridors crossing the Project Area in this period included the Black and Yellow Trail, the Texas Cattle Trail, and the Cheyenne-Deadwood Stage Road.

When the initial Homestead Act of 1862 was passed, the Project Area was Indian territory. In 1877 the Indian threat had been removed and the Desert Land Act was passed. The latter act allowed homestead entries as large as 160 acres, large enough for small livestock operations in this arid region. The first to take advantage of the reopening of the Powder River country were cattle ranchers. Some of the ranches also served as stage stops and roadhouses along the trails. Large, speculative cattle companies overwhelmed the public range land in the 1880s. Sheep also became important soon afterwards, and competed with the cattle. Relations between the sheep and cattle ranchers were strained. The large corporate cattle ranches, which utilized broad areas of open range, also competed for land with towns and homesteaders. The large cattle companies were devastated by the harsh winter of 1886-1887, and already strained relations with sheep ranchers, towns and homesteaders became worse. A major period of conflict in 1892 in

The entry of the Burlington Railroad in the 1890s made travel to the region quicker and less hazardous, and for a time homesteaders and small ranches prevailed. In 1909 the Enlarged Homestead Act was passed, allowing larger homestead entries and an additional surge of homesteaders and small ranchers entered the region. The Stock Raising Homestead Act of 1916, which had less stringent requirements for improvements than the Enlarged Homestead Act, followed this and with the end of the First World War many veterans moved west to claim vacant land. This continued increase in settlement was brought to an end by droughts and agricultural recession in the 1920s and the Great Depression of the 1930s. Many homesteads and small ranches failed, and those that survived did so by absorbing failed ranches and establishing larger and more viable expanses of land. Many more failed ranches and homesteads were bought or reclaimed by the government under the provisions of the Bankhead-Jones Land Utilization Act of 1937.

The Homestead Act of 1862 had included subsurface rights, especially mineral rights, with homestead patents. The later homestead acts partially or entirely reserved federal mineral rights while granting surface rights in the patent. Entries for mineral rights were handled under a separate patent system. The separation of surface and mineral rights and several changes in the mineral patent system have resulted in a complex hodge-podge of surface and subsurface ownership. Extensive areas also have contrasting subsurface mineral rights where different types of minerals are covered by different ownership or control. Areas of contrasting surface and mineral ownership, most often private surface and federal minerals, are referred to as split estate. Such areas are especially common in portions of the Project Area, and result in challenging management problems.

With the establishment of the railroads in the early 1890s coal mining was also emerging as an important element of the regional economy. Sheep and cattle production have remained important elements of the regional economy, but they have been surpassed by mineral and energy development. The onset of the First World War increased the market for oil and coal and these industries expanded. Energy exploration and production were not strongly affected by the agricultural recession of the 1920s. However, the depression of the 1930s did suppress the energy market until the outbreak of the Second World War.

Historic site categories documented for the Project Area are based on broad historic themes. The site categories used in the tables in this document are, Rural, Urban, Mining, Transportation, Military, Exploration, and Communication. Each of these site categories, the types of sites they include, and the importance they may have in history are discussed briefly below.

Rural sites include:

- Small and large ranch/agrarian core complexes
- Outlying ranch/agrarian features (field barns, machinery yards, stock shelters, loadouts, stock ponds or tanks, water control systems, stock herding camps, etc.)
- Homesteads/farmsteads

- Rural community buildings (grange halls, rural schools, rural churches, mercantiles, etc.)

This theme involves historic rural settlement from the expulsion of the Native American tribes in the late 1870s to the early 1950s. Settlement was initially focused around the new or reestablished forts and military camps along the Bozeman Trail. As military and civilian wagon roads and stage roads were established, settlements formed along those arteries. Large corporate ranches soon occupied open lands for grazing and homesteaders also began to spread through the region. There were several cycles of expanded settlement and failure that may be reflected in building styles and materials in surviving structures. More favorable locations were repeatedly reoccupied, and many of the earlier structures were destroyed or modified by later uses. In some cases, each occupation or use episode in a core complex is centered in a slightly different location, and the earlier episodes retain a degree of spatial and structural integrity. Some marginal locations may retain fairly unmodified sites reflecting discrete settlement episodes, although it is a common practice to reuse abandoned buildings for stock shelters or other purposes.

Important parts of rural settlement were rural community buildings including churches, schools, and community halls such as grange halls. In some cases all of these functions were combined in a single building that might be located on a State-owned section or on land provided by one of the landowners. These types of buildings were also commonly located in small communities that served the nearby farms and ranches, as well as serving as political or economic centers at various levels. Many of the rural community buildings began to fall into disuse with the development of motorized traffic and maintained public roads. This is clearly manifested in the centralization of public schools with the development of busing.

These kinds of sites are important for their association with the broad patterns of settlement and development in this region. They represent the homesteads, small and large ranches, small communities, and support facilities that characterized these patterns. Some are important because of their association with specific historic events or the contributions of persons important in history. Others are rare surviving examples representing once common patterns. Some may be important for their potential to yield information important in history that is not available in written documents.

Urban sites include:

- Urban Architecture/Buildings
- Courthouse; Government and Community Buildings
- Dance Hall; Saloon Café/Diner;
- Fairgrounds; Parks
- Home; House; Residence
- Hotel/Lodge;
- Store; Commercial Building
- Church;

- Power Plant;
- Warehouses

This theme involves the emergence of towns. Towns developed as commercial or political centers and are characteristically a mix of residential, commercial, and public buildings. Industrial or industrial support facilities may also be an important element of a town. As energy development and railroads entered the region, towns formed along or moved to the railroad as railheads and transfer points, or formed near mines or well fields as residential areas for laborers and as centers for supply and support services. Urban architecture is more varied than rural architecture, partly because there is generally a wider range of functions represented, and partly because a greater financial base is expressed in more current or elaborate styles. Urban buildings and structures may also exhibit more time sensitive styles than rural vernacular buildings and structures, and may be more easily associated with particular periods or themes.

Mining sites, which includes liquid mineral and energy development, include:

- Mine;
- Mining Support Facilities;
- Tipple;
- Loadout;
- Well Field;
- Energy Exploration

The mining theme includes energy and mineral development facilities. The most conspicuous of these facilities are surface mine complexes, loadouts, and tipples. Oil and gas facilities are generally more dispersed than surface mine complexes. Earlier mines were often abandoned and not reclaimed. Although foundations or deteriorated structures may remain, equipment was typically moved to new mine locations or salvaged over the years. Old mines and oil fields are best identified through mineral claims and public records. Even if little remains in the way of surface structures and associated artifacts, these sites reflect changes in mining strategy and technology in the patterns of landscape modification.
Transportation sites include:

- Overland Migration Corridor/Emigrant Trail;
- Inscriptions;
- Tie Hack Camp;
- Trail/Stage Route;
- Stage Station;
- Freight Road;
- Airstrip;
- Ferry;
- Bridge;

- Road;
- Railroad

This theme represents changes in the patterns and technology of transportation from early historic trails that often followed prehistoric trails, to the emergence of trucks and automobiles and maintained public roads. The early trappers trails and emigrant roads had locations along them that could be called points of convergence. These might be river crossings, low passes, water sources, sources of wood, areas of good pasture, or landmarks. Between these points the trails might vary with the season, the whim of the traveler, or other conditions, and were more like broad swaths across the landscape than marked roads or trails as we might envision today. With more regular freight wagon routes and stage lines, roads were improved and maintained. When the railroads entered the scene, these were necessarily engineered corridors that responded to a different set of economic needs and to different design constraints.

Military sites include:

- Military Camp/Cantonment;
- Blockhouse/Powder Magazine;
- Battlefield/Battle Site;
- Military Fort;
- Proving Grounds;
- Air Bases;
- Chemical and Weapons Depots;
- Missile Silos

The military theme covers evidence of military camps and installations, support facilities, and sites of battles, beginning with the military encampments of the 1860s up through the military facilities of the Cold War. In the project area military sites are clustered along the Bozeman Trail corridors. Many of these sites are not conspicuous on the landscape, but must be identified from historic accounts and detailed surface inspection.

Exploration sites include:

- Fur Trade Cabin;
- Trading Post;
- Trade Beads;
- Expedition Camps;
- Survey Marker

The theme of exploration covers early exploration of the region by fur traders, government expeditions, early travelers, and railroad or General Land Office surveyors. These sites may be comparatively small and transient but are generally either locations described in historic accounts that may or may not be marked by physical remains, or sites marked by distinctive early historic artifacts, including goods made for Indian trade or trapping paraphernalia.

Communication sites include:

- Telegraph/Telephone Lines;
- Pony Express Stations;
- Transmission Lines

These sites represent early communications systems and energy distribution systems. They may be marked by little more than occasional insulator fragments or remnants of crudely hewn poles. Pony Express stops often need to be identified from historic sources. Some were little more than a rural shack and a corral, others were located at existing ranches, and many others became stage stops, retaining little to identify them as Pony Express stops.

Other sites consist of site types that occur in small numbers in the Project Are and do not fall in any of the themes listed above. Sites that have been counted in this category include:

- CCC Camp/Conservation Site;
- Hatchery;
- Monument;
- Prison Camp;
- Lumber Mill;
- Timber Camp;
- Shooting Range;
- Burial/Cemetery/Grave;
- Cairns;
- Historic Camp;
- Dump/Trash Scatter

The Wyoming guidelines also define historic periods that crosscut the themes and site types listed above. The major periods are:

- Early Historic (AD 1800 to 1842)
- Pre-Territorial (AD 1842 to 1868)
- Territorial (AD 1868 to 1890)
- Expansion (AD 1890 to 1920)
- Depression (AD 1920 to 1939)
- Modern (AD 1939 to present)

Evaluation of the importance of historic sites, districts and landscapes must consider aspects of both theme and period in assessing the historic character and contributing attributes of the resources.

Native American Traditional Cultural Places

General ethnographies of the Lakota, Crow, Mandan, Hidatsa, Arikara, Cheyenne, Arapaho, Shoshone, and other tribes that may have had traditional ties to this region do not provide information on specific resources in the Project Area that are likely to be traditional cultural concerns. There are certainly prominent and identifiable places to the west in the Big Horn Mountains and to the east in the Black Hills area. Probably the most widely known examples would be the Big Horn Medicine Wheel and Devils Tower. The known sacred and traditional places offer some indications of the types of places valued by the Plains Equestrian cultures in the historic period. However, any identification of sacred or traditional localities must be verified in consultation with authorized tribal representatives.

Conspicuous landmarks, prominences, and high locations were often held in reverence. It would be reasonable to assume that Pumpkin Buttes, several of the more distinctive or isolated buttes throughout the Project Area, and distinct rock formations in the Middle Fork and Red Wall country were traditionally important places. Some of these natural features may have associated rock art, cairns, offering sites, vision quest sites, or other tangible evidence of traditional importance, while others may be embedded in oral traditions.

Distinctive natural water bodies and confluences of flowing streams and rivers were held by many tribes to be sources of power and inspiration, and mirrors of the inner spirit. The presence of flowing water or bodies of water and high isolated locations such as buttes in close proximity to one another were sometimes considered especially powerful or close to the spirits. These kinds of locations were commonly used for fasting or vision quests. Some vision quest sites that were used repeatedly over the generations have physical features, such as cairns, small stone circles, offerings, small clusters of stone, or stone alignments, in addition to the character of their physical setting.

At a smaller scale, traditional rock art marks localities that were important or sacred to past populations and the rock art itself is a traditional concern to most existing tribes. Similarly stone intaglios and effigies, some rock alignments, and many ancient rock cairns mark traditionally significant locations. Any location with cobble effigy figures, unusually small or large stone circles or medicine wheels, geometric stone alignments, or prominent cairns should be considered a potential sacred or traditional site. Tribes may also hold alignments and cairns associated with more mundane functions such as trails and game drives to be sacred or traditionally important, and may also consider most archaeological sites to be traditional cultural places important to their tribal identity. Several of the tribes that have traditional ties to the Project Area consider "tipi rings" (i.e., stone circle sites) to be sensitive sites that may have spiritual or sacred associations. Traditional tribal concerns can also include traditional gathering areas for medicinal and ceremonial materials.

Files Search

A files search for all four counties (Campbell, Converse, Johnson, and Sheridan) was conducted through the Wyoming Cultural Records Office database in late

March of 2001. This files search covers most investigations in the four counties through the year 2000. The database of cultural resource reports, cultural resource sites, and isolated finds was then narrowed to the project area and subdivided by sub-watershed. This database contains records for 8,120 cultural resource sites, and 2,831 isolated finds. Of the total cultural resource reports in the files search 2,359 were completed prior to 1983 when statewide standards were implemented for cultural resource investigations and reporting. Some of those earlier reports might not be considered adequate by current standards and must be reviewed individually to evaluate their adequacy. Nonetheless, they provide information that might not be otherwise available on the nature and distribution of prehistoric and historic resources. A comparison of the surveyed acres listed in the files search and the total acreage of the Project Area indicates that approximately 10 percent of the Project Area has been investigated. Using this information, estimates can be made of the quantity of significant cultural resource sites that are likely be encountered in the projected area of potential effect of the proposed oil and gas development.

Table 3–49 and Table 3–50 list the numbers of prehistoric and historic cultural resource sites that have been documented in each of the sub-watersheds in the Project Area by site type or historic theme, and by National Register evaluation. Table 3–51 lists the number of isolated finds documented in each of the sub-watersheds. The files search for this area contains a high proportion of sites that are unevaluated or for which information on evaluation is lacking – 35.6 percent for prehistoric and 35 percent for historic. The files search tables show 13 percent of the prehistoric sites and 9.6 percent of the historic sites as listed or eligible. Typically, when adequate information is available, about 10 to 15 percent of the documented sites in an area are evaluated as eligible.

Artifact scatters dominate prehistoric sites in the Project Area. When there is adequate information to evaluate this type of site, the majority are not eligible. However, complex sites and sites with buried levels and dateable materials/artifacts can yield important information. Prehistoric sites in the category of "camp" are a combination of artifacts and features, or a range of artifact types. These sites are more often field evaluated as eligible than simple artifact scatters. The small categories of multi-component/stratified, habitation features, rock features, bone beds/scatters, and rock art are high profile categories that are very often evaluated as eligible. Bone beds and stratified sites that are key in our understanding of all periods of Plains prehistory occur in the project area. Subwatersheds where there have been more studies and more follow up studies, such as Antelope Creek, Upper Cheyenne, and Upper Belle Fourche, have a lower proportion of unevaluated sites. This is especially true of large coal mine developments. Areas within some of the subwatersheds have more varied habitats, particularly attractive resources, or conditions more conducive to preservation, and are very rich in significant prehistoric sites. This includes the Upper Tongue, the Middle Fork Powder, the lower Antelope Creek Drainage, and the eastern portions of the Upper Belle Fourche.

Table 3–49 Prehistoric Site Types by Sub-watershed

Sub-watershed	Evaluation	Artifact Scatter[1]	Camp[2]	Multi-Component	Habitation Features[3]	Rock Features[4]	Bone[5]	Rock Art	Lithic Source	Features Only	Human Bone	Unknown	Total	%[6]
Little Bighorn River	Eligible	0	0	0	0	0	0	0	0	0	0	0	0	0
	Unevaluated	2	0	0	0	0	0	0	0	0	0	0	2	66.7
	Not Eligible	1	0	0	0	0	0	0	0	0	0	0	1	33.3
	Total	3	0	0	0	0	0	0	0	0	0	0	3	<.1
Upper Tongue River	Eligible	3	8	0	1	0	0	0	0	0	0	0	12	5.6
	Unevaluated	69	41	1	25	4	3	2	8	3	0	0	156	72.9
	Not Eligible	26	12	0	4	3	0	0	1	0	0	0	46	21.5
	Total	98	61	1	30	7	3	2	9	3	0	0	214	4.0
Middle Fork Powder River	Eligible	24	78	0	6	2	2	5	8	0	0	0	125	29.4
	Unevaluated	66	41	0	15	5	2	2	12	0	1	1	145	34.1
	Not Eligible	77	63	0	2	4	0	0	9	0	0	0	155	36.5
	Total	167	182	0	23	11	4	7	29	0	1	1	425	7.7
North Fork Powder River	Eligible	0	1	0	0	0	0	0	0	0	0	0	1	25.0
	Unevaluated	2	0	0	0	0	0	0	0	0	0	0	2	50.0
	Not Eligible	1	0	0	0	0	0	0	0	0	0	0	1	25.0
	Total	3	1	0	0	0	0	0	0	0	0	0	4	<.1
Upper Powder River	Eligible	1	43	0	2	0	6	0	0	0	0	0	52	6.5
	Unevaluated	124	81	1	22	0	3	0	5	4	0	0	240	30.0
	Not Eligible	288	199	0	12	4	2	0	2	2	0	0	509	63.5
	Total	413	323	1	36	4	11	0	7	6	0	0	801	15
South Fork Powder River	Eligible	2	0	0	0	0	1	0	0	0	0	0	3	17.4
	Unevaluated	4	5	0	2	0	0	0	0	1	0	0	12	52.2
	Not Eligible	4	3	0	0	0	0	0	0	0	0	0	7	30.4
	Total	10	8	0	2	0	1	0	0	1	0	0	22	.4
Salt Creek	Eligible	2	1	0	1	0	0	0	0	0	0	0	4	6.2
	Unevaluated	10	14	0	7	3	0	1	1	0	0	0	36	55.4
	Not Eligible	16	4	0	0	5	0	0	0	0	0	0	25	38.4
	Total	28	19	0	8	8	0	1	1	0	0	0	65	1.2

Table 3–49 Prehistoric Site Types by Sub-watershed

Sub-watershed	Evaluation	Artifact Scatter[1]	Camp[2]	Multi-Component	Habitation Features[3]	Rock Features[4]	Bone[5]	Rock Art	Lithic Source	Features Only	Human Bone	Unknown	Total	%[6]
Crazy Woman Creek	Eligible	3	5	0	2	0	1	1	0	0	0	0	12	12.2
	Unevaluated	14	15	0	12	0	0	1	2	0	0	1	45	45.9
	Not Eligible	19	10	0	7	4	0	0	0	0	1	0	41	41.9
	Total	36	30	0	21	4	1	2	2	0	1	1	98	1.8
Clear Creek	Eligible	3	6	0	3	0	0	0	0	0	0	0	12	9.7
	Unevaluated	10	14	0	27	2	3	0	2	1	0	1	60	48.4
	Not Eligible	24	10	0	5	9	0	0	4	0	0	0	52	41.9
	Total	37	30	0	35	11	3	0	6	1	0	1	124	2.3
Middle Powder River	Eligible	2	1	0	0	0	0	0	0	0	0	0	3	2.3
	Unevaluated	33	37	0	6	0	0	0	2	0	0	0	78	61.5
	Not Eligible	40	5	0	2	0	2	0	0	0	0	0	49	36.2
	Total	75	43	0	8	0	2	0	2	0	0	0	130	2.4
Little Powder River	Eligible	11	40	0	16	1	5	0	0	0	0	1	74	13.6
	Unevaluated	66	21	1	26	2	3	0	3	0	0	0	122	22.4
	Not Eligible	256	33	0	29	9	7	0	12	1	1	1	349	64.0
	Total	333	94	1	71	12	15	0	15	1	1	2	545	9.9
Little Missouri River	Eligible	0	1	0	0	0	0	0	0	0	0	0	1	5.3
	Unevaluated	2	1	0	2	0	0	0	0	0	0	0	5	26.3
	Not Eligible	6	7	0	0	0	0	0	0	0	0	0	13	68.4
	Total	8	9	0	2	0	0	0	0	0	0	0	19	.3
Antelope Creek	Eligible	53	122	1	20	0	2	0	2	2	1	0	203	23.0
	Unevaluated	125	49	0	28	14	3	1	0	5	1	0	226	25.6
	Not Eligible	298	104	0	38	11	1	0	2	0	0	1	455	51.4
	Total	476	275	1	86	25	6	1	4	7	2	1	884	16.1
Dry Fork Cheyenne River	Eligible	1	32	0	11	1	1	0	1	0	0	0	47	11.1
	Unevaluated	58	58	0	59	50	2	0	1	2	0	0	230	54.4
	Not Eligible	90	31	0	11	7	3	0	4	2	0	0	148	34.5
	Total	149	121	0	81	58	6	0	6	4	0	0	425	7.7

Table 3–49 Prehistoric Site Types by Sub-watershed

Sub-watershed	Evaluation	Artifact Scatter[1]	Camp[2]	Multi-Component	Habitation Features[3]	Rock Features[4]	Bone[5]	Rock Art	Lithic Source	Features Only	Human Bone	Unknown	Total	%[6]
Upper Cheyenne River	Eligible	8	28	0	5	2	3	0	0	0	1	0	47	9.4
	Unevaluated	51	30	1	19	2	2	0	5	0	0	0	110	21.2
	Not Eligible	289	47	1	12	5	4	0	3	0	0	0	361	69.7
	Total	348	105	2	36	9	9	0	8	0	1	0	516	9.4
Lightning Creek	Eligible	3	15	0	2	0	0	0	0	0	0	0	20	8.8
	Unevaluated	80	29	0	12	4	3	0	1	0	0	0	129	56.6
	Not Eligible	54	19	0	4	2	0	0	0	0	0	0	79	34.6
	Total	137	63	0	18	6	3	0	1	0	0	0	228	4.1
Upper Belle Fourche River	Eligible	15	26	0	25	2	0	0	0	0	0	0	68	9.0
	Unevaluated	109	33	1	53	23	8	0	7	5	0	1	240	31.7
	Not Eligible	284	88	0	63	10	1	0	3	0	0	0	449	59.3
	Total	408	147	1	141	35	9	0	10	5	0	1	757	13.8
Middle North Platte River	Eligible	2	19	0	7	0	1	0	0	0	0	0	29	11.9
	Unevaluated	21	36	0	48	17	0	0	0	1	0	0	123	50.6
	Not Eligible	40	31	0	8	5	1	0	5	0	0	0	91	37.5
	Total	63	86	0	63	22	2	0	5	1	0	0	242	4.4
Total Eligible Sites		135	426	1	102	8	22	6	11	2	2	1	716	13.0
Total Unevaluated Sites		846	505	5	363	126	32	7	49	22	2	4	1961	35.6
Total Sites		2792	1597	7	661	212	75	13	105	29	6	7	5504	100
Per cent of Total Sites		50.8	29.0	0.1	12.0	3.9	1.4	0.2	1.9	0.5	0.1	0.15	100	

Notes:
1. Artifact Scatters are predominantly lithic (i.e. chipped stone tool) scatters in this region, but also includes ground stone, ceramics, and composite artifact scatters.
2. Camp includes sites encoded as open camp, habitation, or artifacts and features.
3. Habitation Features includes stone circles, open architecture, structures, lodges, and rockshelters. The most common of the latter are stone circles.
4. Rock Features includes cairns, hunting blinds, rock alignments, and other non-habitation rock features.
5. Bone includes bone beds, bone scatters, kill sites, and butchering sites.
6. % is given as percent Eligible for each subwatershed and then percent of total sites represented by the subwatershed.

Table 3–50 Historic Site Types by Historic Theme and Sub-watershed

Sub-watershed	Evaluation	Rural	Urban	Mining	Transportation	Military	Exploration	Communication	Other	Unknown	Total	%
Little Bighorn River	Eligible	0	0	0	3	0	0	0	0	0	3	60
	Unevaluated	0	0	0	0	0	0	0	0	0	0	0
	Not Eligible	1	0	0	1	0	0	0	0	0	2	30
	Total	1	0	0	4	0	0	0	0	0	5	0.2
Upper Tongue River	Eligible	8	11	3	13	4	0	0	0	1	40	16.9
	Unevaluated	37	13	14	2	5	1	0	9	12	93	39.2
	Not Eligible	12	60	8	22	0	0	0	2	0	104	43.9
	Total	57	84	25	37	9	1	0	11	13	237	10.5
Middle Fork Powder River	Eligible	8	1	0	1	1	0	0	0	1	12	12.1
	Unevaluated	34	6	0	2	0	0	0	8	6	56	56.6
	Not Eligible	16	1	0	2	0	0	0	11	1	31	31.3
	Total	58	8	0	5	1	0	0	19	8	99	4.4
North Fork Powder River	Eligible	1	0	0	0	0	0	0	0	0	1	50
	Unevaluated	0	0	0	0	0	0	0	0	0	0	0
	Not Eligible	0	0	0	0	0	0	0	1	0	1	50
	Total	1	0	0	0	0	0	0	1	0	2	<.1
Upper Powder River	Eligible	10	0	0	13	2	0	0	3	1	29	8.5
	Unevaluated	74	1	2	3	4	1	0	10	23	118	34.7
	Not Eligible	120	0	2	13	0	1	0	49	8	193	56.8
	Total	204	1	4	29	6	2	0	62	32	340	15.1
South Fork Powder River	Eligible	1	0	0	1	0	0	0	1	0	3	18.8
	Unevaluated	1	1	0	0	0	3	0	1	1	7	43.7
	Not Eligible	2	0	0	4	0	0	0	0	0	6	37.5
	Total	4	1	0	5	0	3	0	2	1	16	.7

Table 3–50 Historic Site Types by Historic Theme and Sub-watershed

Sub-watershed	Evaluation	Rural	Urban	Mining	Transportation	Military	Exploration	Communication	Other	Unknown	Total	%
Salt Creek	Eligible	0	0	0	2	0	0	0	0	0	2	7.1
	Unevaluated	6	0	0	2	0	0	0	0	1	9	32.2
	Not Eligible	5	0	1	6	0	0	0	5	0	17	60.7
	Total	11	0	1	10	0	0	0	5	1	28	1.2
Crazy Woman Creek	Eligible	1	0	0	6	1	0	0	1	0	9	12.7
	Unevaluated	18	1	2	2	0	2	0	3	1	29	40.8
	Not Eligible	17	0	1	8	0	0	0	5	2	33	46.5
	Total	36	1	3	16	1	2	0	9	3	71	3.1
Clear Creek	Eligible	16	8	0	6	3	0	0	1	1	35	19.7
	Unevaluated	32	12	4	5	0	0	0	4	12	69	38.7
	Not Eligible	15	10	3	39	0	0	2	5	0	74	41.6
	Total	63	30	7	50	3	0	2	10	13	178	7.9
Middle Powder River	Eligible	2	0	0	0	0	0	0	0	0	2	5.5
	Unevaluated	18	0	0	0	0	0	0	1	0	19	52.8
	Not Eligible	7	1	0	2	0	0	0	5	0	15	41.7
	Total	27	1	0	2	0	0	0	6	0	36	1.6
Little Powder River	Eligible	9	0	0	0	0	1	0	0	0	11	5.8
	Unevaluated	49	2	0	2	0	0	0	6	5	64	33.7
	Not Eligible	66	2	2	10	0	0	0	22	13	115	60.5
	Total	124	4	2	12	0	1	0	29	18	190	8.4
Little Missouri River	Eligible	0	0	0	0	0	0	0	0	0	0	0
	Unevaluated	3	1	0	1	0	0	0	1	1	7	70
	Not Eligible	2	0	0	0	0	0	0	0	1	3	30
	Total	5	1	0	1	0	0	0	1	2	10	.4
Antelope Creek	Eligible	14	1	0	4	0	0	0	2	2	23	7.9
	Unevaluated	37	1	2	0	0	0	0	16	13	69	23.5
	Not Eligible	123	0	5	6	1	0	0	55	11	201	68.6
	Total	174	2	7	10	1	0	0	73	26	293	13.0

Table 3–50 Historic Site Types by Historic Theme and Sub-watershed

Sub-watershed	Evaluation	Rural	Urban	Mining	Transportation	Military	Exploration	Communication	Other	Unknown	Total	%
Dry Fork Cheyenne River	Eligible	3	0	0	2	0	0	0	1	0	6	4.1
	Unevaluated	50	0	0	3	0	0	0	20	7	80	54.8
	Not Eligible	32	0	1	4	1	0	0	18	4	60	41.1
	Total	85	0	1	9	1	0	0	39	11	146	6.5
Upper Cheyenne River	Eligible	4	0	0	1	0	0	0	3	0	8	4.8
	Unevaluated	13	0	0	2	0	0	0	7	8	30	18.0
	Not Eligible	85	0	1	7	0	0	0	35	1	129	77.2
	Total	102	0	1	10	0	0	0	45	9	167	7.4
Lightning Creek	Eligible	2	0	0	0	0	0	0	0	0	2	3.9
	Unevaluated	8	0	0	0	0	0	0	3	10	21	41.2
	Not Eligible	15	0	0	0	0	0	0	11	2	28	54.9
	Total	25	0	0	0	0	0	0	14	12	51	2.3
Upper Belle Fourche River	Eligible	17	0	0	5	3	0	0	1	1	27	8.6
	Unevaluated	37	1	4	4	0	0	0	9	18	73	23.3
	Not Eligible	130	3	4	10	0	0	0	47	19	213	68.1
	Total	184	4	8	19	3	0	0	57	38	313	13.9
Middle North Platte River	Eligible	0	0	0	4	0	0	0	0	0	4	5.6
	Unevaluated	34	0	0	1	0	0	0	8	1	44	61.1
	Not Eligible	14	0	0	4	0	0	0	4	2	24	33.3
	Total	48	0	0	9	0	0	0	12	3	72	3.2
Total Eligible Sites		96	21	3	61	14	1	0	14	7	217	9.6
Total Unevaluated Sites		451	39	28	29	9	7	0	106	119	788	35.0
Total Sites		1209	137	59	228	25	9	2	395	190	2254	100
Per cent Total Sites		53.6	6.1	2.6	10.1	1.1	0.4	<0.1	17.5	8.4	100	

Table 3–51 Number of Isolated Finds by Sub-watershed

Sub-watershed	Isolated Finds			
	Prehistoric	Historic	Unknown	Total
Little Bighorn River	1	0	0	1
Upper Tongue River	25	0	7	32
Middle Fork Powder River	82	2	14	98
North Fork Powder River	1	1	0	2
Upper Powder River	437	57	80	574
South Fork Powder River	1	10	8	19
Salt Creek	22	3	3	28
Crazy Woman Creek	13	4	5	22
Clear Creek	17	5	0	22
Middle Powder River	33	1	2	36
Little Powder River	227	8	25	260
Little Missouri River	2	0	0	2
Antelope Creek	462	24	127	613
Dry Fork Cheyenne River	137	2	20	159
Upper Cheyenne River	216	7	30	253
Lightning Creek	30	0	9	39
Upper Belle Fourche River	408	40	82	530
Middle North Platte River	111	1	29	141
Total	2,225	165	441	2,831

Rural/agrarian sites dominate known historic sites because that is where the majority of systematic surveys have been conducted. These include homesteads, farms, ranches, agrarian and ranching features, irrigation features, and rural residences. The principal exception to this is the Upper Tongue River sub-watershed in which a large number of urban buildings and structures have been documented in Sheridan. The next most common site type is transportation features, which includes trails, roads, bridges, railroads, stage stations, railroad stations, and related structures or features. Where historic military sites, early exploration sites, and early transportation sites have been recognized and documented, most are considered significant because of their associations with significant historic events. Urban buildings and structures are often recorded as part of surveys of significant historic buildings, rather than in response to unrelated actions. This also produces a moderately high proportion of sites evaluated as eligible. The Bozeman Trail, its several variants, and related sites, were highly significant in western history and retain a large number of well-preserved segments. The Outlaw Cave/Red Wall area of the Middle Fork Powder River is rich in prehistoric caves and rockshelters, premiere prehistoric rock art sites, prehistoric stone features, and historic sites that figure prominently in Western lore. The proportion of significant historic sites is high in most categories and these sites require additional work beyond basic field recording. In addition, many of the historic sites are unevaluated and require additional background or context research to assess their eligibility.

Native American Consultation

Federal legislation including but not limited to 36 CFR §800 implementing Section 106 of the National Historic Preservation Act, as amended, and the Native American Graves Protection and Repatriation Act (NAGPRA), requires consultation with recognized Native American tribes. Within the Project Area this includes the Apache, Northern Arapaho, Crow, Northern Cheyenne, Arikara, Mandan, Hidatsa, Kiowa, Shoshone, Salish and Kootenai, Turtle Mountain Chippewa, and Lakota (Sioux) tribes. The BLM has notified tribes that may have traditional interests and concerns in the region of the EIS process. A meeting hosted by the Cheyenne River Sioux and attended by members of the Cheyenne River Sioux Tribe and Oglala Lakota Tribe was held in South Dakota in April 2001 and the Sicangu Lakota Treaty Council of the Rosebud Sioux Tribe has expressed concern about the project. The tribes will be cooperating or consulting parties in the EIS process.

Land Use and Transportation

Land Use

This section discusses the existing land surface and mineral ownership, land uses, and land use management and planning in the Project Area.

Regional Characterization

The BLM-administered lands within the Project Area include both the BFOA and the CFOA. In Campbell, Johnson, and Sheridan Counties, BLM lands within the Project Area are administered by the BFO. For the northern potion of Converse County within the Project Area, BLM lands are administered by the CFO.

FS-administered lands in the Project Area include portions of the TBNG administered by the Medicine Bow-Routt National Forest. The TBNG is located in the eastern portions of Campbell and Converse Counties.

Land ownership in the Project Area consists primarily of private lands intermingled with federal and state lands as shown on Figure 3–15. Mineral ownership in the Project Area consists primarily of federal mineral estates as shown on Figure 3–16. Rangeland/livestock grazing is the dominant land use for both public and private lands in the Project Area. The management of planned future land uses within the Project Area is also discussed for BLM- and FS-administered lands, state-owned lands, and the local governments.

Land Status/Surface Ownership

The distribution of surface ownership of the land within each watershed of the Project Area is summarized in Table 3–52 and shown on Figure 3–15.

Approximately 76 percent of the surface ownership in the Project Area is private land. The State of Wyoming owns approximately 9 percent of the surface land

ownership within the Project Area. Federal land comprises approximately 14 percent of the Project Area.

Federal lands within the Project Area are administered by the BLM BFO and CFO and the FS, and consist of numerous noncontiguous tracts of land surrounded by private lands. Approximately 10 percent of the lands within the Project Area are federally owned within the BFOA. Within the CFOA, approximately one percent of the land is federally owned. FS-administered lands in the area include portions of the TBNG administered by the Medicine Bow-Routt National Forest. The TBNG is located in the eastern portions of Campbell and Converse Counties. A total of approximately three percent of the lands within the FS-administered lands within the Project Area are federally owned.

Mineral Ownership

The mineral estate (mineral ownership) within the Project Area is shown in Figure 3–16. Many areas of the Project Area are considered to be "split-estate", meaning the surface owner is different from the owner of the mineral rights. For example, the surface may be privately owned but the mineral estate is at least in part, federally owned. In addition, there may be more than one owner among the different mineral estates. For example, the federal government may own only the oil and gas mineral resources, while coal and/or other mineral resources on the same lands are owned by the state or private parties. Under the current management situation, CBM is managed by the federal government as an oil and gas right, rather than a coal right.

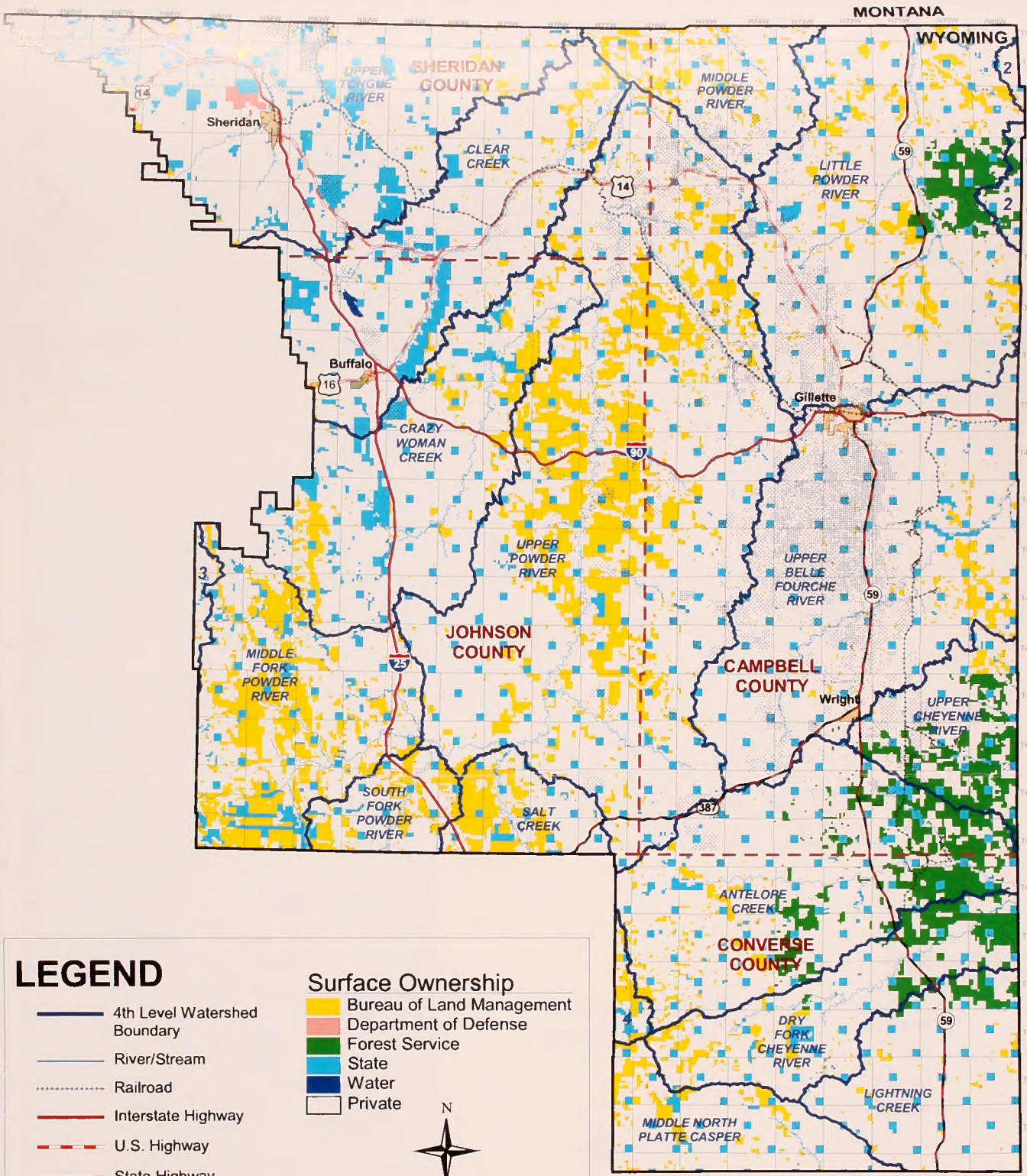
The mineral ownership within each watershed in the Project Area is shown on Table 3–53.

The mineral ownership categories shown in Table 3–53 include several categories that must be combined to determine the total federal ownership for oil and gas rights. Total oil and gas ownership includes the sum of properties with federal ownership of all mineral rights; oil and gas rights only; oil, gas and coal rights only; and oil, gas, coal and other minerals (but not all mineral rights). The mineral category "other" includes locatable minerals (bentonite, uranium, and others) and salable minerals (sand, gravel and scoria).

The majority of the oil and gas mineral estates within the Project Area are federally owned. Within the BFOA, approximately 63 percent of the oil and gas mineral estate within the Project Area is federally owned. Approximately 63 percent of the oil and gas minerals for that portion of the Project Area within the CFOA are federally owned. Within the FS-administered lands of the Project Area, approximately 52 percent of the oil and gas rights are under federal ownership.

Existing Land Uses

Several primary land uses occur within the Project Area as shown on Figure 3–17, and as discussed in the following sections. The land use categories for the BLM-administered lands for both the BFOA and the CFOA, and the FS-administered lands within the Project Area are shown in Table 3–53, and summarized in the following discussion.



LEGEND

- 4th Level Watershed Boundary
- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary
- Existing CBM Wells

Surface Ownership

- Bureau of Land Management
- Department of Defense
- Forest Service
- State
- Water
- Private

N

Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers

Sub-Watersheds

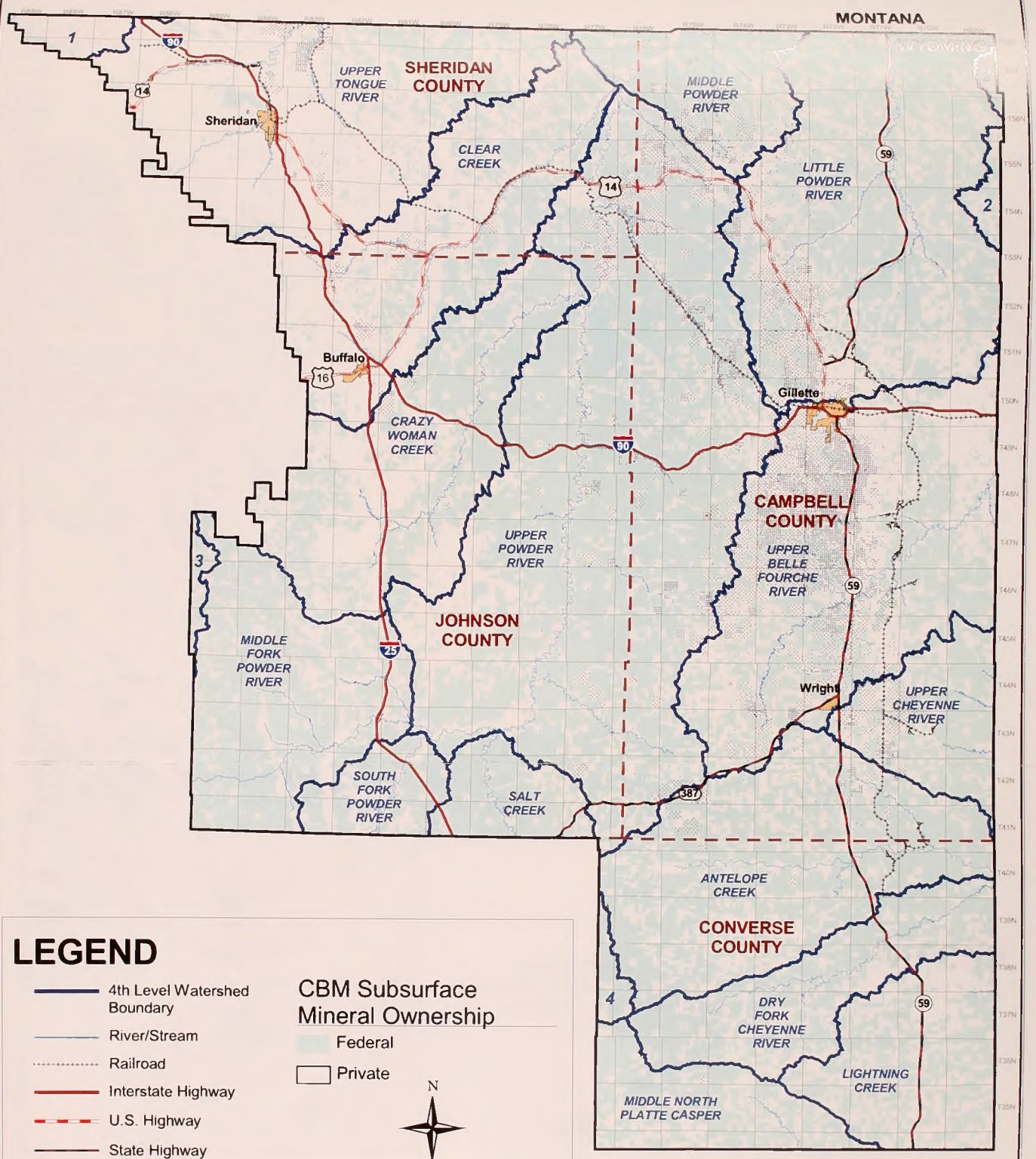
1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 3-15 SURFACE OWNERSHIP	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/14/01	ArcView File: C:\1011_v1\data\maps.apr Layout--Surface Ownership
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

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LEGEND

- 4th Level Watershed Boundary
- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary
- Existing CBM Wells

CBM Subsurface Mineral Ownership

- Federal
- Private

N

Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 3-16 CBM MINERAL OWNERSHIP	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/14/01	ArcView File: C:\1011_v1\data\maps.apr Layout--MineralOwnership
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

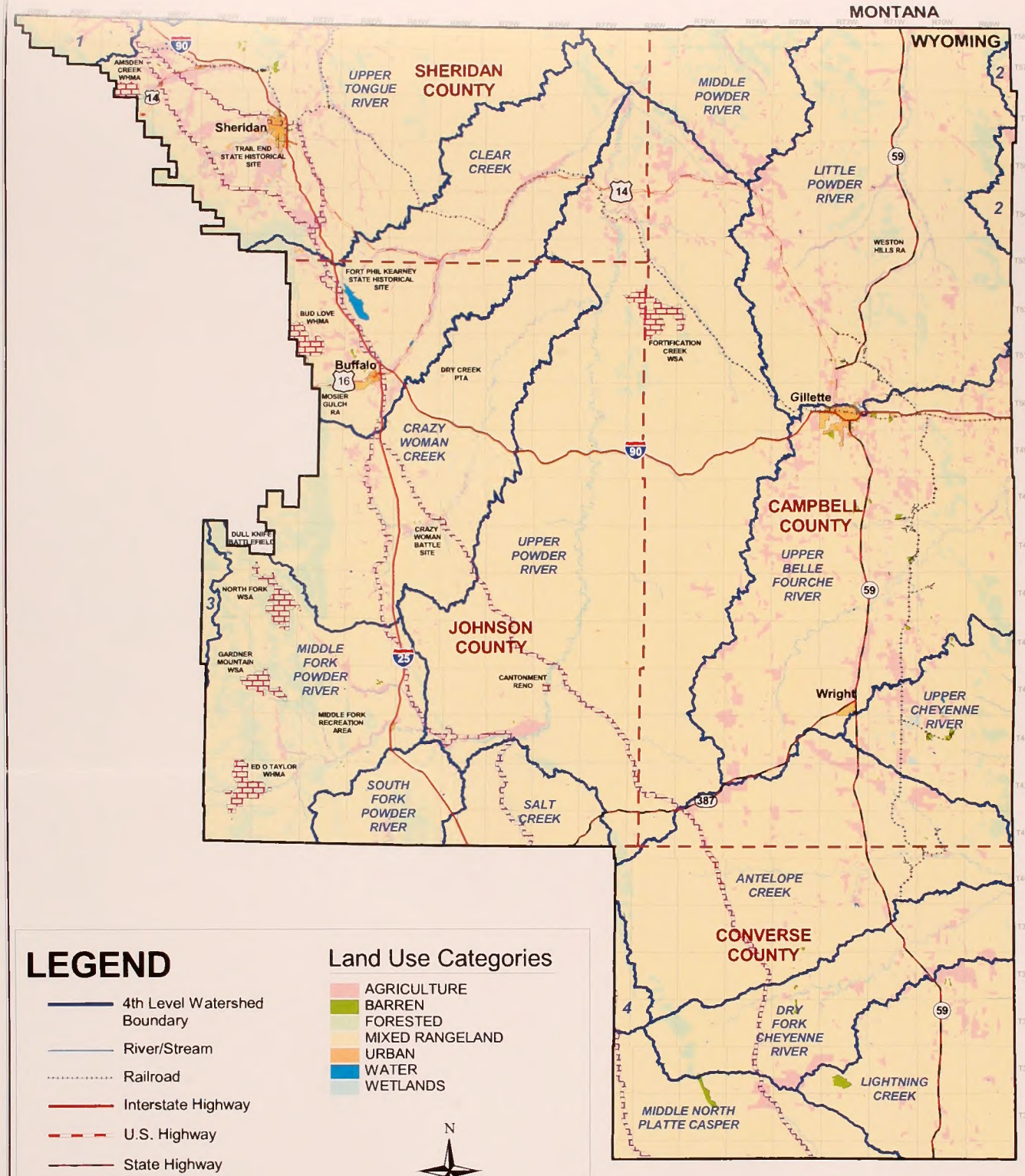
Transverse Mercator Projection 1927 North American Datum Zone 13

Table 3–52 Surface Ownership by Watershed

	Areal Extent (acres)					Portion of Project Area (percent)					
	Federal					Federal					
	BLM					BLM					
Watershed	BFO	CFO	FS	State	Private	Total	BFO	CFO	FS	State	Private
Little Bighorn River	425	0	0	3,671	45,489	49,585	1	0	0	7	92
Upper Tongue River	13,393	0	0	91,682	634,817	739,892	2	0	0	12	86
Middle Fork Powder River	149,835	0	0	47,905	266,716	464,456	32	0	0	10	57
North Fork Powder River	1,401	0	0	1,148	18,125	20,675	7	0	0	6	88
Upper Powder River	329,326	199	0	99,969	1,174,045	1,603,539	21	0	0	6	73
South Fork Powder River	31,849	0	0	8,452	74,056	114,357	28	0	0	7	65
Salt Creek	42,544	10,534	0	14,374	84,909	152,362	28	7	0	9	56
Crazy Woman Creek	55,585	0	0	65,106	427,599	548,289	10	0	0	12	78
Clear Creek	22,541	0	0	70,610	454,332	547,483	4	0	0	13	83
Middle Powder River	34,008	0	0	11,258	178,967	224,232	15	0	0	5	80
Little Powder River	75,216	0	43,024	59,324	687,928	865,492	9	0	5	7	79
Little Missouri River	378	0	6,932	2,932	28,286	38,528	1	0	18	8	73
Antelope Creek	735	27,172	101,373	48,509	482,517	660,306	0	4	15	7	73
Dry Fork Cheyenne River	0	20,825	46,093	106,843	218,645	392,405	0	5	12	27	56
Upper Cheyenne River	4,679	0	61,717	13,422	126,988	206,806	2	0	30	6	61
Lightning Creek	0	6,522	14,196	17,995	269,612	308,325	0	2	5	6	87
Upper Belle Fourche River	29,405	0	290	55,610	759,568	844,873	3	0	0	7	90
Middle North Platte Casper	0	28,500	0	14,251	169,825	212,576	0	13	0	7	80
Total	791,321	93,752	273,625	733,058	6,102,425	7,994,181	10	1	3	9	76

Table 3–53 Mineral Ownership

Watershed	Federal Coal	Federal Other	Federal Oil & Gas	Non-federal Oil & Gas	Total Oil & Gas	Portion of Area (percent) Federal Oil & Gas	Portion of Area (percent) Non-federal Oil & Gas
BFO							
Little Bighorn River	5,400	0	5,209	44,376	49,585	11	89
Upper Tongue River	343,088	772	142,412	597,481	739,892	19	81
Middle Fork Powder River	324,872	3,291	326,299	138,156	464,456	70	30
North Fork Powder River	13,782	0	14,776	5,898	20,675	71	29
Upper Powder River	1,407,909	986	1,092,495	507,509	1,600,004	68	32
South Fork Powder River	73,321	2,502	75,716	38,641	114,357	66	34
Salt Creek	98,097	0	98,732	26,362	125,093	79	21
Crazy Woman Creek	344,758	0	271,617	276,673	548,289	50	50
Clear Creek	325,853	384	173,022	374,461	547,483	32	68
Middle Powder River	205,941	0	153,922	70,310	224,232	69	31
Little Powder River	610,614	1	452,259	340,542	792,801	57	43
Little Missouri River	3,791	1	4,769	10,982	15,751	30	70
Antelope Creek	49,910	263	38,390	21,067	59,457	65	35
Dry Fork Cheyenne River	0	0	0	0	0	0	0
Upper Cheyenne River	47,388	343	27,143	27,608	54,751	50	50
Lightning Creek	0	0	0	0	0	0	0
Upper Belle Fourche River	663,769	1,424	323,341	499,584	822,925	39	61
Middle North Platte Casper	0	0	0	0	0	0	0
Total	4,518,494	9,966	3,200,101	2,979,651	6,179,751	52	48
CFO							
Little Bighorn River	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0
Upper Powder River	2,651	0	2,651	884	3,534	75	25
South Fork Powder River	0	0	0	0	0	0	0
Salt Creek	22,741	0	22,741	4,527	27,268	83	17
Crazy Woman Creek	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0
Antelope Creek	179,960	121	155,170	75,652	230,821	67	33
Dry Fork Cheyenne River	104,365	565	100,987	56,384	157,372	64	36
Upper Cheyenne River	0	0	0	0	0	0	0
Lightning Creek	161,923	4,721	143,238	129,314	272,552	53	47
Upper Belle Fourche River	0	0	0	0	0	0	0
Middle North Platte Casper	144,288	485	140,933	71,643	212,576	66	34
Total	615,927	5,892	565,720	338,404	904,123	63	37
FS							
Little Bighorn River	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0
Upper Powder River	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0
Little Powder River	47,645	10,281	47,645	25,047	72,691	66	34
Little Missouri River	11,185	2,990	11,185	11,592	22,777	49	51
Antelope Creek	311,821	15,149	247,687	122,341	370,028	67	33
Dry Fork Cheyenne River	109,509	15,415	94,887	57,061	151,948	62	38
Upper Cheyenne River	123,790	10,141	97,593	54,461	152,054	64	36
Lightning Creek	18,770	12,886	10,378	25,395	35,773	29	71
Upper Belle Fourche River	20,469	0	11,784	10,165	21,949	54	46
Middle North Platte Casper	0	0	0	0	0	0	0
Total	643,189	66,862	521,159	306,061	827,220	63	37
Grand Total	5,777,609	82,720	4,286,979	3,624,116	7,911,095	54	46



LEGEND

- 4th Level Watershed Boundary
- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary
- No Surface Occupancy
- Bozeman Trail Corridor

Land Use Categories

- AGRICULTURE
- BARREN
- FORESTED
- MIXED RANGELAND
- URBAN
- WATER
- WETLANDS

N

Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers

Sub-Watersheds

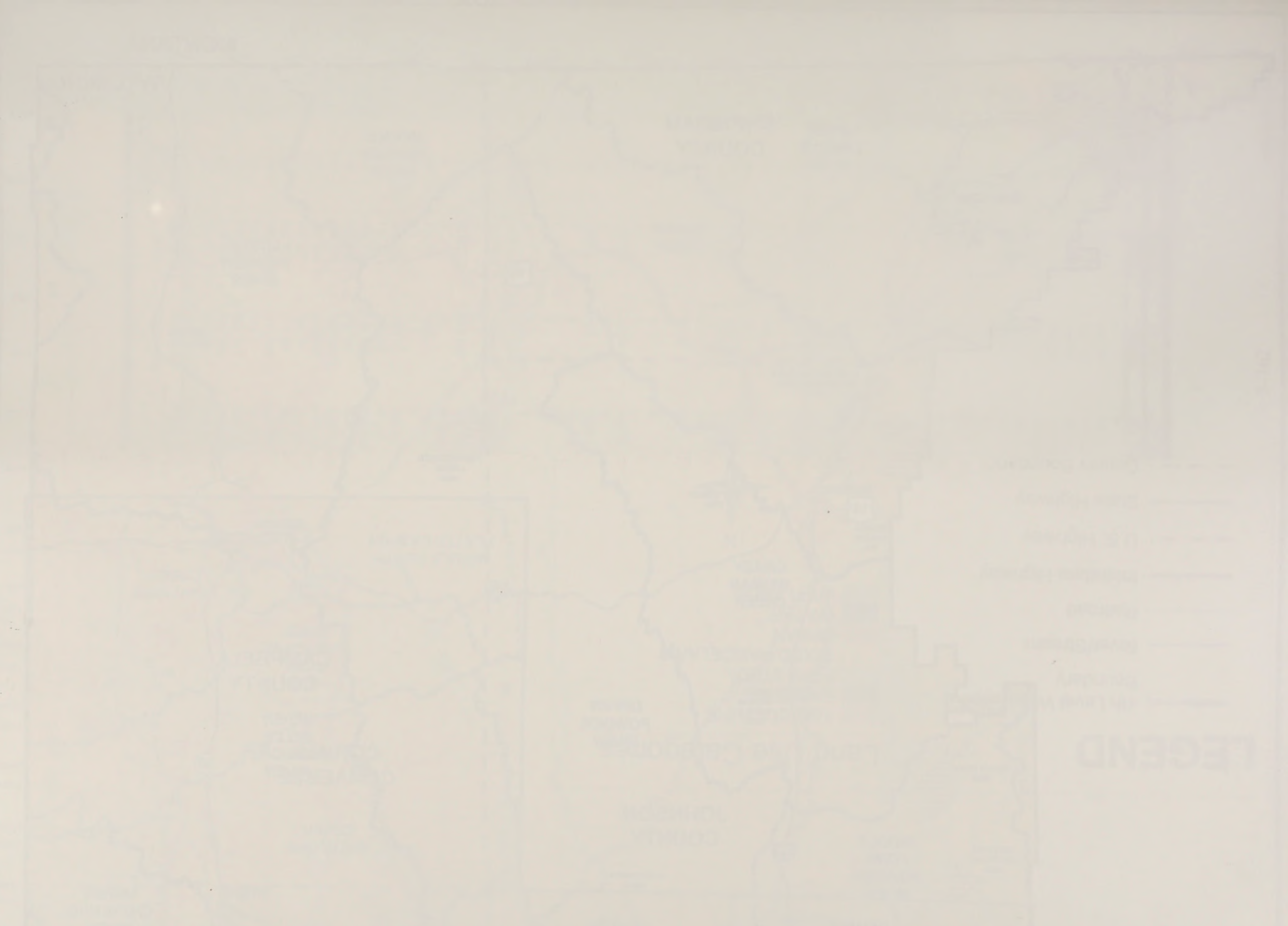
1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 3-17 LAND USE AND RECREATION SITES	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/14/01	ArcView File: C:\1011_v1\data\maps.apr Layout--Land Use
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection 1927 North American Datum Zone 13



Rangeland and Forest Land

Rangeland is generally used for livestock operations and grazing, and is the dominant land use in the Project Area. The primary use of the BLM- and FS-administered forest lands within the Project Area is also grazing. The forest land category shown on Figure 3–17 includes deciduous, evergreen, wetland/riparian, and mixed forest land.

Agriculture

Agricultural land uses within the Project Area include cropland and pasture, confined feeding operations, and other agricultural uses. Most of the cropland in the Project Area is not irrigated; however, irrigated cropland occurs in limited areas, primarily adjacent to drainage ways.

Urban and Residential

Urban land uses within the Project Area include residential, industrial/ commercial areas, and transportation, communications, and utility ROWs, as well as transitional areas, as shown on Figure 3–17.

Although rural residences are scattered throughout the Project Area, residences are primarily concentrated in the areas within and immediately adjacent to the incorporated areas of Project Area. The incorporated communities within the Project Area include Gillette and Wright in Campbell County; Douglas and Glenrock in Converse County; Buffalo and Kaycee in Johnson County; and Sheridan in Sheridan County. Additional residential areas within the Project Area are also concentrated in the vicinity of numerous unincorporated communities.

The transportation and utility corridors for the Project Area are shown on Figure 3–17. The transportation network and railroad corridors are discussed in the Section on Transportation.

Existing Oil and Gas Development

Approximately 12,077 CBM wells are already permitted or drilled on federal, state, and private lands within the Project Area. Existing CBM wells, non-CBM well, conventional oil and/or gas wells within the Project Area are discussed in the section on groundwater (beginning on page 3–1).

Mines

The locations of the coal strip mines within the Project Area are shown on Figure 2-1. Existing producing coal mines are discussed in the section on coal (beginning on page 3–38). There are historic mines for coal, uranium, bentonite, and aggregate materials (sand and gravel) within the Project Area. Within the Project Area, oil and gas resources are frequently located in the same general vicinity as coal resources. Federal coal lands being considered as having development potential are primarily in the easternmost portion of the Project Area (BLM 2001).

Recreation

Recreational sites and facilities within the Project Area are discussed in the section on recreation (beginning on page 3–182) and shown on Figure 3–17. Public lands within the Project Area are generally available for dispersed recreational

land uses. Several developed recreational facilities are located in special management areas (SMAs) on BLM-administered lands (see Table 3–61). Although no developed campgrounds are located in the FS-administered lands within the TBNG, this area provides land use opportunities for recreational activities.

Land Use Planning and Management

Land use planning and management are described generally in this section for lands administered by the BLM, FS, State of Wyoming, and the four counties encompassed by the Project Area. Public lands administered by the BLM and FS are generally available for oil and gas leasing, exploration and development.

Existing federal (BLM and/or FS) oil and gas leases within the Project Area contain various stipulations concerning surface disturbance, surface occupancy, limited surface use, and timing (seasonal) restrictions. These lease stipulations provide for the imposition of such reasonable conditions, not inconsistent with the purposes for which the lease was issued, as the BLM and or FS may require, to protect the surface of the leased lands and the environment. Mitigation measures can be imposed upon a lessee who pursues surface-disturbing activities; however, leased land without a No Surface Occupancy (NSO) or other similarly restrictive lease stipulation cannot be denied a permit to drill.

Within the Project Area, oil and gas estates are frequently located in the same vicinity as coal resources. Oil and gas leases are generally issued with special lease stipulations to help prevent a development conflict with coal. These stipulations may require as conditions of approval that a plan of mitigation of anticipated impacts be negotiated between the oil and gas and coal lessees prior to surface use. Coals mines in the Project Area are discussed under coal on page 3–38.

BLM Land Management

Overall BLM land management is described in detail in Chapter 5. Thus, this discussion focuses on more specific, smaller-scale management units.

Several BLM SMAs that provide recreational opportunities are located within the Project Area (Figure 3–17). These areas include the Fortification Creek SMA and Fortification Creek Wilderness Study Area (which is encompassed by the larger Fortification Creek SMA), and several additional Wilderness Study Areas (WSAs). Oil and gas leases are not issued with surface occupancy rights (for drilling, access routes, or production facilities) within WSAs to preserve the wilderness values. Surface disturbances are also restricted within Recreational Areas (RAs) and Wildlife Habitat Management Areas (WHMAs). WHMAs are managed in cooperation with the WGFD. The BLM land use planning and management goals for these areas are also discussed in the section on recreation (beginning on page 3–182).

Because oil and gas resources are frequently located in the same vicinity as coal resources, oil and gas leases are generally issued with special stipulations to help prevent a development conflict with coal resources. These stipulations may require that a plan of mitigation of anticipated impacts be negotiated between the oil and gas and coal lessees before surface use. The current BLM oil and gas stipulation (BLM 2001) prohibits or restricts surface occupancy or use within

areas of conflict with ongoing coal mining activities. In addition to standard lease terms, special stipulations identifying specific terms and conditions of use may be attached to oil and gas leases, where needed to protect specific natural resources.

The BLM has also SMAs within the Project Area. They include the South Big Horns Area, the Dry Creek Petrified Tree Environmental Education Area, the Fortification Creek Area, the Weston Hill Recreation Area, and the Mosier Gulch Recreational Area. These SMAs were defined to manage for values and resources specifically identified with each SMA.

National Forest Land Management

Numerous land parcels within the TBNG are scattered throughout Campbell and Converse counties in the Project Area. Although the Bighorn National Forest is on the western boundary of the Project Area, none of the Bighorn National Forest lands are within the Project Area. Most of the CBM resources on the FS land within the Project Area are located in the westernmost portion of the TBNG.

Under the 1987 Federal Onshore Oil and Gas Leasing Reform Act, FS lands that are available for oil and gas leasing were identified, along with the stipulations that are considered to be appropriate to protect surface resources. The FS administers the land uses on National Forest System lands based on multiple use principals.

The Douglas Ranger District of the Medicine Bow-Routt National Forest administers the public lands and activities within the TBNG. Oil and gas leasing and development activities on FS-administered federal lands within the TBNG are allowed, subject to the limitations imposed by the LRMP for the Medicine Bow National Forest and TBNG (FS 1985). Actions proposed within the TNBG must be in conformance with the management goals within the LRMP (FS 1985).

The FS completed an FEIS and issued a ROD in 1994 for Oil and Gas Leasing on the TBNG (FS 1994). In 1994, the FS developed many special leasing restrictions for oil and gas activities within the TBNG. Leasing restrictions applicable to drilling or production activities within the TBNG may be included as conditions of approval for APDs on post-1994 leases. The restrictions outlined in the site-specific environmental effects analyses must contain documentation at to whether or not proposed development is consistent with the 1994 FEIS/ROD and the 1985 LRMP.

The 1999 Proposed LRMP for the TBNG (Forest Plan) provides the proposed land use guidelines for the eight management areas within the TBNG. Most of the FS land within the Project Area is managed for livestock grazing. The FS also has special stipulations to protect identified resources within FS-administered lands.

Federal Lands Grazing Allotments

Most of the BLM and FS lands within the Project Area are used for livestock grazing under permitted grazing allotments. Livestock grazing is not allowed in specified areas due to conflicts with other uses, such as big game winter ranges,

and timber sale areas. Grazing allotments are classified by BLM into one of three management categories. These categories in priority order are: maintain (M), improve (I), and custodial (C). M category allotments have high production potential where no resource use conflicts have been identified. I category allotments have a high production potential but are producing below the potential level. C category allotments are generally isolated or scattered parcels of public land interspersed with nonfederal lands, and have little potential for multiple use management or positive economic returns. Most of the public land in the Project Area is in the M and I management categories.

Each BLM grazing allotment is classified by how many animal unit months (AUMs) are provided by the acreage in the allotment. AUMs are defined as the amount of forage to sustain one cow and calf for one month.

BLM requires land use activities within allotment areas to comply with the specific standards and guidelines for healthy rangeland in cooperation with the State of Wyoming (BLM 1997). Wyoming BLM Mitigation Guidelines (BLM 1995) are also employed to avoid and mitigate impacts and conflicts among resources and land uses for surface-disturbing activities on BLM-administered lands in Wyoming.

Wyoming State Land Management

The State Land Use Planning Act (W.S. 9-849 through 9-862) was enacted by the Wyoming legislature in 1975, and established the State Land Use Commission to guide land use planning in the state. The Office of State Lands and Investments, the administrative and advisory arm of the Board of Land Commissioners and State Loan and Investment Board, is responsible for oil and gas leases, and easements within and temporary uses of state lands.

The state-owned lands in the Project Area are generally available for mineral and agricultural leasing, timber leasing and sales, and public recreation. State Trust Lands are lands granted by the federal government to the State of Wyoming to generate revenues for the benefit of designated beneficiaries. These beneficiaries are the common (public) schools, universities, and other public institutions in Wyoming (Wyoming 1996).

The Wyoming State Land Commissioners, Office of Land and Investments, administers oil and gas leases and developments on state-owned lands in Wyoming. State Trust Lands are managed to generate revenues that are reserved for the benefits of designated beneficiaries, including the public schools, universities, and public institutions in Wyoming. State-owned lands in the Project Area are generally available for mineral and agricultural leasing and sales, and public recreation.

The WOGCC regulates drilling and well spacing, and requires an approved APD for all oil and gas wells drilled in the State of Wyoming regardless of land ownership, including wells on federal lands. The ADP approval process includes securing the necessary legal access to and /or across state- or privately-owned lands.

Campbell County Land Use Planning and Local Governments

Within Campbell County, the City of Gillette and the Town of Wright have zoning ordinances and land use plans for the incorporated areas. Planned future land uses within Campbell County are addressed in the City of Gillette/Campbell County Comprehensive Planning Program and shown on the Campbell County Zoning District Map (City of Gillette and Campbell County Planning Commission 1994). Adjacent to and outside of the city limits of the City of Gillette, Campbell County has designated zoning districts, including numerous subdivisions, and designated suburban and rural residential districts (Campbell County 2000a and 2000b). The unincorporated portions of the county outside of the Gillette Planning District are considered to be "Open District" zoning or agricultural (Bryson 2001).

Construction within the jurisdictional areas of the City of Gillette or other incorporated areas within the Project Area requires additional permitting with the local government agencies. The City of Gillette zoning regulations (City of Gillette 1992) define oil, gas and mineral exploration and production activities as "permitted uses" within the agricultural or heavy industrial districts within the city limits. Oil and gas production activities require City Council permission and must meet the applicable provisions in the Gillette Municipal Code. Permits are required from the City of Gillette for construction within the city limits, or the use of existing ROWs and easements dedicated or owned by the city. City noise ordinances would apply to drilling or construction operations within the city limits.

Numerous residential developments exist in the areas surrounding the City of Gillette, but outside of the incorporated area. If CBM development is proposed near any of these developments, current permitting requirements and stipulations would apply.

There are similar permits and mitigation measures would be required for CBM activities within the jurisdictional area of the Town of Wright (Town of Wright 1998) and other incorporated areas within the Project Area.

Johnson County Land Use Planning and Local Governments

Johnson County currently does not have a countywide zoning districts, land use districts, or a comprehensive land use plan, although they are in the process of developing one (Yingling 2001). The communities of Buffalo and Kaycee have land use plans for the urban areas. The Buffalo/Johnson Joint Land Use Plan was adopted August 2001, and is currently under revision. This plan primarily addresses land uses adjacent to the residential areas within less than ten miles from Buffalo.

The Powder River Conservation District Long Range Program Resource Conservation and Land Use Plan , adopted February 10, 1998 also provides land use guidance primarily to prevent erosion of soils for the southern half of Johnson County.

Sheridan County Land Use Planning and Local Governments

Development within the unincorporated portions of Sheridan County is regulated by the Sheridan County Zoning Resolution (Sheridan County 2001a), and the Sheridan County Growth Management Plan (2001b). With the exception of several designated growth areas in the vicinity of the existing residential developments, the anticipated future land uses and current zoning for most of the county is agricultural (Springer 2001). Designated growth areas are defined for the areas in the immediate vicinity of the City of Sheridan, Town of Clearmont, and the unincorporated urban and residential communities of Story/Banner, Big Horn, Big Goose Valley, Ranchester/Dayton, and Arvada (Sheridan County 2001b). The City of Sheridan has designated zoning districts for the incorporated areas (City of Sheridan 2000).

Within Sheridan County, a buffer zone area of several miles adjacent to and east of the Big Horn National Forest is designated as a Resource Conservation Area on the Sheridan County Comprehensive Plan Land Use Map (Sheridan County 1999). In addition, a low-density development area is identified surrounding the City of Sheridan, including and extending south of the community of Big Horn. These planning areas are not currently addressed in the Sheridan County Zoning Resolution (Sheridan County 2000b).

Converse County Land Use Planning and Local Governments

The Project Area is within the northwestern portion of Converse County and north of Interstate 25. Within the Project Area, the Converse County Land Use Plan (Converse County 1978) describes the current land use as primarily agriculture, predominantly dryland (nonirrigated) grazing. Mineral extraction is the current secondary use for this portion of the county. Mineral extraction is exempted from local regulations; however, mineral processing is regulated to minimize conflicts between mineral extraction and historic surface land uses. Converse County does not currently have countywide zoning. The city zoning ordinances for Douglas and Glenrock have development requirements (Musselman 2001a).

Transportation

The existing public road network, BLM roads, county transportation planning, and other transportation are discussed in the following sections. Scenic byways, areas designated for off road vehicle (ORV) use, and historic transportation corridors, are discussed in the Section on Recreation. Public lands are accessible via public roads and/or across private land that requires landowner permission.

Public Road Network

Gillette and Sheridan are the hubs for the transportation network in the Project Area. Interstate highways in the Project Area include I- 25 and I-90. The major north-south transportation corridors include State Route 59 in Campbell and Gillette Counties, and I-25 in Johnson and Sheridan Counties. The principal east-west highway for Campbell and Johnson Counties is I-90. I-90 runs north from the Town of Buffalo to the City of Sheridan, and then continues north to the Montana State line. U.S. Highways in the Project Area include U.S. Routes 14, 16 to the East of Buffalo, and 87. The Primary State Highways in the Project

Area are Routes 59, and 387. Secondary State Highways traversing the area include Routes 50, 51, 192, 196, 338, and 450. Numerous county roads also provide local access to public and private lands within the Project Area.

Recent annual average daily traffic counts (ADT) suggest use of highways and roads in the Project Area is highly variable (Table 3–54). Not surprisingly, the Interstates and major highways account for the highest ADTs.

BLM Road Design and Maintenance

There are numerous improved and unimproved (four-wheel drive) roads within the Project Area. BLM transportation planning for both the Buffalo and Casper resource districts is discussed in the 1985 RMPs, and in the updates to these documents (BLM 1985a and b, 2001a and b).

Table 3–54 Annual Average Daily Traffic Counts

County	Route Name	Description	Annual ADT 1998	Annual ADT 1999
Campbell	I-90	Sheridan-Johnson County Line	5,700	5,970
	I-90	Wyodak Intersection	5,660	5,790
	I-90	Gillette East Urban Limits	5,970	6,100
	I-90	WYO 59 Int.	6,070	6,380
	US 14-16	Rozet Intersection	5,100	5,320
	WYO 50	Savageton	500	550
	WYO 59	Gillette South of Urban Limits	18,690	17,760
	WYO 59	Johnson-Campbell County Line	1,110	1,210
	WYO 59	Wright	2,150	2,250
	WYO 59	Converse-Campbell County Line	1,350	1,450
	WYO 59	Wyoming-Montana State Line	300	300
	WYO 387	Johnson-Campbell County Line	1,110	1,210
Converse	I-25	Platte-Converse County Line	5,500	5,980
	WYO 59	Bill	1,350	1,450
Johnson	I-90	Junction US 25 (Buffalo Tri-level Intersection)	3,680	3,700
	I-90	Johnson-Campbell County Line	5,030	5,140
	I-25 & US 87	Junction Kaycee Interchange	2,800	2,802
	US 16	Johnson-Sheridan County Line	260	280
Sheridan	I-90	Sheridan-Johnson County Line	5,700	5,970
	I-90 & US 87	Wyoming-Montana State Line	3,710	3,760
	US 14-16	I-90	2,400	2,400
	US 14-16	Ucross Junction	560	560
	US 14-16	Sheridan-Campbell County Line	180	180
	WYO 336	Sheridan East Urban Limits	4,100	4,200
	WYO 338	Sheridan North Urban Limits	1,050	1,050

Source: WDOT 1999

Based on the BLM Manual, Section 9113 (BLM 1985c), roads on BLM lands are classified, based on the amount of traffic movement, into three road classes, consisting of temporary, resource, local, and collector roads. Collector roads generally provide access to large land tracts and are the major access routes into development areas with high average daily traffic rates. They usually connect with or are extensions of public road systems and are operated for long-term land uses. Local roads normally serve a smaller area and lower traffic volume than collector roads. They connect with collectors or public road systems. In mountainous ter-

rain, local roads may be single lane roads with turnouts. Resource roads are generally point access or spur roads that connect with local or collector roads, and carry low traffic volumes.

BLM minimum road design and maintenance requirements are provided in BLM Manual Section 9113 – Roads (BLM 1985c) and the BLM Wyoming Supplement (BLM 1991). Road routes, locations, and design criteria are included in the APD and/or ROW applications. For oil and gas roads, the operators must provide the BLM with copies of all road maintenance agreements. Because some operators do not need access to sites during winter months, snow removal is generally a separate maintenance agreement item.

State of Wyoming Road Access Permits and Maintenance

Prior to construction of new roads that are to access an existing state or county road, an access permit must be obtained from the Wyoming Department of Transportation (WYDOT). The application form for an access permit must include location of proposed road construction, and roadway design specifications, including type of surface material, drainage structures, roadway width, profile and grades.

Snow removal operation performed by the WYDOT is primarily mechanical, using snow plows, and fences (Milburn 2001b). An aggregate (sand) and salt mixture is generally used for tunnels and areas requiring deicing.

Many of the existing roads within the Project Area are in need of repairs and/or improvement. In the 2000 Surface Transportation Improvement Program (STIP) compiled by the WYDOT Planning Program, more than 200 highway improvement projects to begin for the year 2000. Major improvements projects scheduled for roads within the Project Area, in the Primary highway category, include widening and resurfacing a section of I-90 west of Gillette. In the Secondary highway category, scheduled improvements include seven miles of US 14-16 northwest of Clearmont, and four miles of WYO 335 between Big Horn and Sheridan. The STIP also provides a projection of the transportation improvements scheduled to occur in the five-year-plus period beginning in 2001.

County Transportation Planning

Transportation plans and goals for the four counties in the Project Area are discussed in this section.

The general planning goals for transportation for Campbell County are discussed in the City of Gillette/Campbell County Comprehensive Planning Program (City of Gillette and Campbell County 1994). Traffic generation and potential conflicts will be considered in evaluating new developments and zoning changes. The County is currently replacing scoria-surfaced roads with river gravel to reduce dust.

Currently, Johnson County has no formal transportation plan.

In Sheridan County, the Comprehensive Plan (Sheridan County 1982) provides a proposed transportation plan for improvement of the roads only for the City of Sheridan and the adjacent growth management area.

Transportation issues identified in the Converse County Land Use Plan (Converse County 1978) include paving and other road improvements that may be required due to increased traffic from increased rural residential development and mineral extraction and processing in rural areas. Gravel roads were previously suitable.

Other Transportation

Rail service and airports within the Project Area are discussed in the following sections.

Rail Service

The Project Area has one major railroad. In Sheridan County, the Burlington Northern/Santa Fe Railroad runs north-south from the Montana State line through the City of Sheridan, and then east through Clearmont, and continues east to the City of Gillette in Campbell County. The railroad then travels east of the City of Gillette, and runs north-south through Converse County. Several spur lines connect the railroad with historic mines in the area. In the BFOA, the average ROW width for the railroad is 400 feet (BLM 2001).

Airports

Three public airports exist in the Project Area (AirNav.com 2001). The Gillette-Campbell County Airport is located approximately four miles northwest of Gillette. The VOR (radio aid used for navigation) is located at the airport. The Sheridan County Airport is located on the west side of the City of Sheridan. All development within the Sheridan County designated Airport Zone must comply with the Airport Master Plan (Sheridan County 1975). The Johnson County Airport is located approximately three miles northwest of Buffalo.

Federal Aviation Administration (FAA) regulations require a two-mile radius safety zone around airports to promote air navigational safety at the airport, and to reduce the potential for safety hazards for property and for persons on lands near airports. FAA regulations also require filing a notice (FAA Form 7460-1) for construction projects which extend 200 feet or greater above natural terrain and located within five miles of an airport. Portions of Project Area are located within two-mile safety zones for these airports.

Visual Resources

Regional Characterization

The Project Area consists of public, state and private lands in Sheridan, Campbell, Johnson, and part of Converse County in northern Wyoming. The Project Area lies in the Powder River Basin portion of the Great Plains physiographic province and is bordered by the Big Horn Mountains to the west and the Black Hills to the east.

The Project Area landscape is comprised of open grasslands, low rolling hills, and unobstructed views of many miles. Most of the Area is covered with dryland vegetation consisting of grasses and shrubs. Ponderosa pine covers large portions of the northeast quarter of the Project Area. Outside the urban areas of Sheridan, Gillette, Buffalo, and Wright, the Project Area is characterized by a rural landscape that has been modified by oil and gas field developments, coal mines, grazing, and urban areas. Grazing activities are evident in most of the Project Area. Highways, county roads, private roads, and utility lines also are evident throughout the Project area. Portions of the Project Area remain natural and undeveloped in character despite widespread mineral development and grazing activities. Most of the Project Area landscape is composed primarily of scenery that is common for the region.

General Visual Characteristics

Oil and gas pumping units and associated well pads and access roads are evident throughout the Project Area. The majority of existing well development occurs in the eastern half of the Project Area in 40 and 80-acre well spacing patterns. Well development is most evident in Campbell County between the cities of Gillette and Wright, and north, west, and northwest of Gillette. Development is also evident along Interstate 90 and State Highway 14 and 93 in Campbell and Sheridan Counties. The landscape that has resulted from ongoing oil and gas development in this area is rural/industrial in character. The wells are intrusive (defined as readily visible) and visually dominant in foreground (one-quarter to one-half mile from observer) views from roads and trails. In middleground (generally one-half mile to three miles) and background (more than three miles) distance zones, well pads and associated access road clearings are the most obvious feature of oil and gas developments. Clearings are visible as light brownish gray exposed soils in geometrically shaped areas with straight, linear edges that provide textural and color contrasts with the surrounding undisturbed vegetation. In general, oil and gas facilities are visually subordinate to the landscape in middle to background distance zones.

The majority of areas with significant scenic values occur in the western part of the Project Area. The South Big Horns Area is located in the southwest quarter of Johnson County, primarily within the Middle Fork Powder River sub-watershed. The area provides sensitive and unique resource values, including scenery. Special management areas within the South Big Horns Area include the Middle Fork Recreation Area, the Red Wall/Hole-in-the-Wall area, Outlaw Cave, Dull Knife Battlefield site, and the Gardner Mountain and North Fork Wilderness Study Areas. The Powder River breaks in eastern Johnson County, the Fortification Creek SMA and WSA, and the Weston Hills Recreation Area in the eastern part of the Project Area also provide scenic settings for a variety of dispersed recreational activities.

There are two scenic byways in the western part of the Project Area that provide access to the Bighorn Mountains. The Bighorn Scenic Byway is on U.S. Route 14 west of Ranchester. The Cloud Peak Skyway is on U.S Route 16 west of Buffalo.

Visual Resource Management

BLM

The BLM has inventoried visual resources for all BLM, state and private land in the Buffalo and Casper Field Office areas according to the Visual Resource Management (BLM 1986b) and established VRM classes. The VRM system is the basic tool used by the BLM to inventory and manage visual resources on public lands. The VRM classes are objectives that outline the amount of disturbance an area can tolerate before it no longer meets the objectives of the class. There are four VRM classes, each of which combine and evaluates visual quality, visual sensitivity of the area, and view distances. The inventory includes state, National Forest, and private lands as well as BLM lands, however the BLM manages visual resources only on BLM lands. Many private and public lands in the area have increased in sensitivity since the last inventory conducted in the 1970s as a result of increases in population and lifestyle shifts that emphasize outdoor recreation. Four VRM classes have been inventoried within the Project Area, as shown on Figure 3–18 and summarized in Table 3–55. The objectives of VRM classes applied to lands within the Project Area are:

- Class II — Class II provides for activities that would not be evident in the characteristic landscape. Contrasts are seen, but must not attract attention. Lands along the base of the Bighorn Mountain foothills in the western part of the Project Area, and lands along Interstate 90 and State Route 14 in the Upper Powder River Sub-watershed are Class II lands. These lands are sensitive to public view.
- Class III — The objective is to provide for management activities that may contrast with the basic landscape elements, but remain subordinate to the existing landscape character. Activities may be visually evident, but should not be dominant. Class II areas occur primarily along major highway corridors such as Interstates 25 and 90, State Route 14, Fortification Creek SMA and WSA, and along a broad corridor at the base of the Big Horn Mountains between Buffalo and the Montana/Wyoming state line.
- Class IV — The objective is to provide for management activities that may require major modifications to the existing landscape. The level of change to the landscape can be high and may be visually dominant. Most of the Project Area is managed with Class IV objectives.
- Class V — This class is applied to areas where the landscape character has been so disturbed that rehabilitation is needed. It should be considered an interim short-term classification until one of the other classes can be reached through rehabilitation or enhancement. Lands currently managed with Class V objectives occur in the vicinity of urban areas of Sheridan, Buffalo, Gillette, and at coal mining areas in the eastern part of the Project Area.

Table 3–55 VRM Inventory for Sub-watersheds in the Powder River Basin Project Area

	Class II		Class III		Class IV		Class V		
Sub-watershed	acres	%	acres	%	acres	%	acres	%	Total
Little Bighorn River	33,315	67.2	16,270	32.8	0	0	0	0	49,585
Upper Tongue River	94,710	12.8	281,987	38.1	352,643	47.7	10553	1.4	739,892
Middle Fork Powder River	265,727	57.2	42,511	9.2	155,788	33.5	429	0.1	464,456
North Fork Powder River	18,901	91.4	1,774	8.6	0	0	0	0	20,675
Upper Powder River	49,484	3.1	183,977	11.5	1,370,078	85.4	0	0	1,603,539
South Fork Powder River	0	0	24,805	21.7	89,551	78.3	0	0	114,357
Salt Creek	0	0	9,634	6.3	142,728	93.7	0	0	152,362
Crazy Woman Creek	53,720	9.8	74,739	13.6	419,830	76.6	0	0	548,289
Clear Creek	40,519	7.4	133,702	24.4	370,443	67.7	2818	0.5	547,483
Middle Powder River	0	0	0	0	224,232	100	0	0	224,232
Little Powder River	0	0	90,611	10.5	746,929	86.3	27953	3.23	865,492
Little Missouri River	0	0	150	0.4	38,378	99.6	0	0	38,528
Antelope Creek	0	0	33,209	5.0	627,097	95.0	0	0	660,306
Dry Fork Cheyenne River	0	0	31,345	10.1	277,975	89.9	0	0	309,320
Upper Cheyenne River	0	0	0	0	183,947	89.0	22859	11.1	206,806
Lightening Creek	0	0	64,528	20.9	243,797	79.1	0	0	308,325
Upper Belle Fourche River	11,320	1.3	93,620	11.1	695,155	82.3	44778	5.3	844,873
Middle North Platte Casper	0	0	0	0	212,576	100	0	0	212,576
Total	567,696	7.2	1,082,862	13.7	6,151,147	77.8	109390	1.4	7,911,096

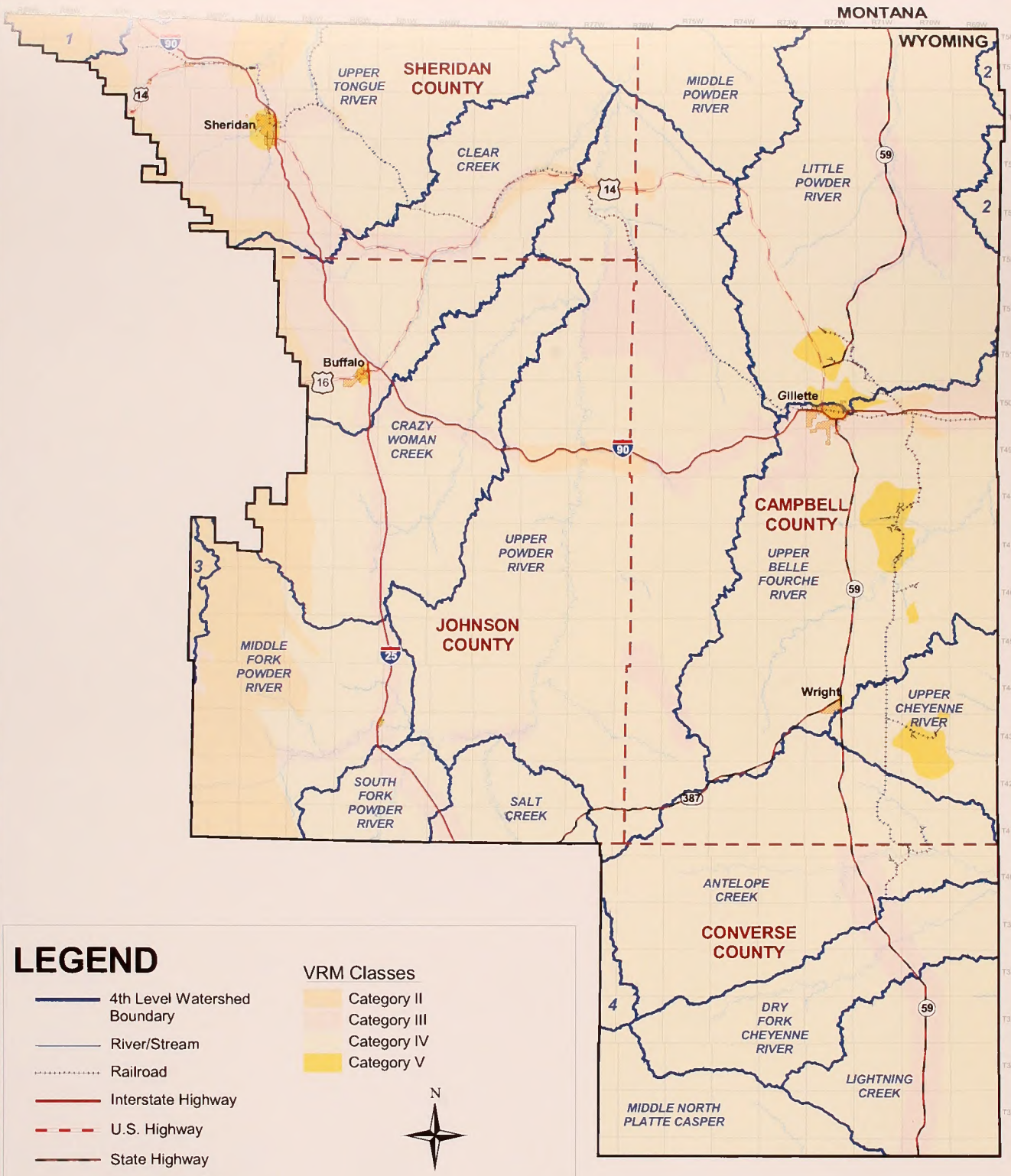
Table 3–56 shows the distribution of 12,077 CBM wells already permitted or drilled on federal, state, and private lands in the Project Area. The majority of permitted wells (10,218 wells, or nearly 85 percent) are on private lands, which is consistent with the distribution of surface ownership in the Project Area (see Land Use and Transportation – Affected Environment). Out of the total VRM inventory of 12,077 wells, only 205 wells (1.7 percent) are on BLM lands. The remaining wells are on state (1,535 wells) or National Forest lands (118 wells). Nearly 84 percent of permitted wells, regardless of land ownership, are in the VRM Class IV inventory.

Coal mining occurs primarily in the east-central part of the Project Area, east and south of Gillette. There are currently 14 active open-pit coalmines in Campbell County, and one coalmine north of the city of Sheridan. Open pit mining results in landscapes that have been altered considerably from the natural topography, consisting of significant contrasts from exposed soils and spoil piles with surrounding vegetation, dust from mining operations, and associated infrastructure such as buildings, rail haulage, and road systems. Coal mines dominate foreground and middleground views in the affected viewsheds, and are generally classified with VRM Class IV or V objectives in the Project Area.

Forest Service

The Medicine Bow-Routt National Forest has developed a Final Land and Resource Management Plan (LRMP) for the TBNG (FS 2001). The Forest has inventoried visual resources under the new Scenery Management System (SMS), which incorporates viewing distance zones, concern level (public importance), scenic attractiveness (indicator of intrinsic scenic beauty of a landscape), scenic class (determined by combining the scenic attractiveness with distance zone and concern levels), and existing scenic integrity (state of naturalness).

Scenic Integrity Objectives (SIO) were assigned to each management area based on the intent of the management area direction. SIOs provide goals for management of grassland and forest scenic resources. There are five SIOs ranging from



LEGEND

- 4th Level Watershed Boundary
- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

VRM Classes

- Category II
- Category III
- Category IV
- Category V

N

Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers

Sub-Watersheds

1--Little Bighorn River
2--Little Missouri River
3--North Fork Powder River
4--Salt Creek

WYOMING

Project Area

POWDER RIVER BASIN OIL & GAS EIS

FIGURE 3-18
VISUAL RESOURCE MANAGEMENT CLASSES

ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming

DATE: 12/14/01

ArcView File: C:\1011_v1\data\maps.apr
Layout:-VRM

DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management--Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection
1927 North American Datum
Zone 13

LEGEND

Table 3–56 Existing Wells in VRM Classes by Sub-watershed in the Powder River Basin Project Area

	Class II		Class III		Class IV		Class V		Total	
SubWatershed	Existing CBM Wells	Disturbance (acres)	Existing CBM Wells	Disturbance (acres)	Existing CBM Wells	Disturbance (acres)	Existing CBM Wells	Disturbance (acres)	Existing CBM Wells	Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	323	1,454	86	387	406	1,827	0	0	815	3,668
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0
Upper Powder River	182	819	197	887	2,429	10,930	0	0	2,808	12,636
South Fork Powder River		0		0		0		0	0	0
Salt Creek	0	0	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	126	567	24	108	0	0	150	675
Clear Creek	12	54	234	1,053	143	644	0	0	389	1,750
Middle Powder River	0	0	0	0	727	3,272	0	0	727	3,272
Little Powder River	0	0	12	54	1,563	7,034	238	1,071	1,813	8,158
Little Missouri River	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	1	4.5	252	1,134	0	0	253	1,138
Dry Fork Cheyenne River		0		0		0		0	0	0
Upper Cheyenne River	0	0	0	0	433	1,948	21	94.5	454	2,043
Lightening Creek		0		0		0		0	0	0
Upper Belle Fourche River	0	0	509	2,290	4,114	18,513	39	175.5	4,662	20,979
Middle North Platte River	0	0	0	0	6	27	0	0	6	27
Total	517	2,327	1,165	5,243	10,097	45,437	298	1,341	12,077	54,346

Note: Disturbance is based on 4.5 acres per well, and includes disturbances associated with ancillary facilities.
Source: BLM 2001

very low to very high. TBNG lands within the Project Area have been inventoried with two scenic integrity levels. The scenic integrity level of Low refers to landscapes where the valued landscape character appears moderately altered. Most of the TBNG lands in the Project area are managed with the scenic integrity level of Low, as the grassland landscape appears moderately altered by oil, gas, and mineral development, and to a lesser extent, some grazing improvements such as fences. The scenic integrity level of Moderate refers to landscapes where the valued landscape character appears slightly altered. A portion of TBNG lands along Antelope Creek and TBNG lands in east of state Highway 59 in Converse County are assigned a scenic integrity level of Moderate.

Visual management objectives for SIOs are associated with desired landscape character for each management area, and are based on the intent of the management area direction. The desired condition for landscapes in each of the seven management areas within the Project Area is summarized in Table 3–57.

Table 3–57 Desired Conditions for TBNG Management Areas in the Project Area

Management Area		Desired Condition for Scenic Values
3.63	Black-Footed Ferret Reintroduction Habitat	na[1]
3.65	Rangelands with Diverse Natural-Appearing Landscapes	Natural appearing landscapes predominate; however, oil and gas facilities may occur and are subordinate to the landscape
3.68	Big Game Range	na
4.32	Dispersed Recreation: High Use	Appears as a natural-appearing landscape over large areas, but modifications on a small scale are acceptable and blend with the area's natural features.
5.12	General Forest and Rangelands: Range Vegetation Emphasis	These areas are dominated by open meadows, grasslands, shrublands and areas of woody vegetation. Signs of motorized travel, hunting, hiking, timber harvest, mining and grazing may be evident.
6.1	Rangeland with Broad Resource Emphasis	na
8.4	Mineral Production and Development	Facilities and landscape modifications are visible but are reasonably mitigated to blend and harmonize with natural features. Reclamation activities restore the area to a reasonable level of its pre-mining condition.

Note:
1. na = not applicable.

Counties

The Sheridan County Growth Management Plan (Sheridan Plan), a comprehensive master plan for the city of Sheridan and all of Sheridan County, was prepared in May of 2001. One of the primary themes identified in the Sheridan Plan is to maintain a community character that preserves the quality of life, values and traditions of the area. The goals and the associated implementation strategies that relate to mineral development for achieving this theme are described below.

Goal D. Maintain Natural and Historic Resources and Environmental Quality

1.D.1 Sheridan County should complete a comprehensive countywide inventory, from existing resources, of environmental, scenic, and historical resources and wildlife habitat. Data should be mapped using a Geographic Information System (GIS). This data should be utilized in the review and evaluation of proposed subdivisions as well as all commercial and industrial development. In the event that resources are impacted by a proposed development, the site would either not be developed or mitigation would be required. Resources to be inventoried should include, but are not limited to:

- Natural or scenic resource areas;
- Land reserved as open space or buffer areas as part of development;
- Linear open space, such as utility and trail corridors;
- Coal bed methane resources areas

The City of Gillette and Campbell County have jointly prepared a Comprehensive Planning Program (Program), last updated March 1994. The Program identifies parks and recreation planning, including landscaping and beautification, as an essential element determining the character and quality of an environment. The Program recommendation is that where industrial areas are located adjacent to residential areas, landscaping should be developed into the buffer zone between two uses.

The General Land Use Plan for Converse County (Converse Plan) was developed in August of 1978. The Converse Plan does not identify any objectives or policies for scenic resources or landscape character in the county. Converse County is currently updating the Land Use Plan.

Johnson County currently does not have a countywide zoning districts, land use districts, or a comprehensive land use plan, although they are in the process of developing one (Yingling 2001). The Buffalo/Johnson Joint Land Use Plan was adopted August 2001, and is currently under revision. This plan primarily addresses land uses adjacent to the residential areas within less than 10 miles from Buffalo. There are currently no goals for the management of scenic resources in the county.

Sensitive Viewing Areas

The level of sensitivity to modifications of the landscape in the Project Area ranges from low to high. Most of the Project area is not visually sensitive due to its remoteness from viewpoints used by the public. The overall population density of the rural portion of the Project Area is low. Visitor use of most public lands in the Project Area is light for recreation or other activities. The portions of the Project Area that have a high level of sensitivity to modification to the landscape occur in the vicinity of communities, along highway corridors, and at recreation-use areas. There are a significant number of residents and visitors exposed to these landscapes who would have a concern for scenic quality, and who would be sensitive to modifications to the landscape. In general, residents and other users of the area are accustomed to viewing existing mineral resource development, but could be sensitive to increased levels of development.

The majority of sensitive areas occur in the western part of the Project Area, including Interstate 25, the cities of Sheridan and Buffalo, and several recreation and historic sites. The Interstate 25 highway corridor, which connects several communities within the Project Area, has the highest levels of traffic of any highway in the Project Area. Recreational use areas are described in the following section on Recreational Resources. Sensitive areas in the remainder of the Project Area include Gillette and recreational use areas in the eastern part of the Project Area. Other travel routes include Interstate 90, several state highways, and numerous county roads and BLM roads that access the area from the highways. Public use of BLM roads is relatively low with motorists falling into the categories of local ranchers and residents, coal mine and gas field personnel, and recreationists.

Recreational Resources

Regional Characterization

The proposed Project Area consists of BLM, Forest Service, state and private lands in four counties in northern Wyoming. A significant portion of each county in the Project Area is public land. Public lands provide open space for a variety of dispersed outdoor recreation opportunities, as well as developed facilities to help meet the demand for site-oriented recreation. Recreation opportunities offered by the private sector consist of community facilities in urban areas and the infrastructure of tourist services and facilities.

The Project Area counties offer broad, panoramic prairie landscapes, which provide a setting for a variety of outdoor recreational activities. Major attractions include the Thunder Basin National Grassland, several State Historic Sites, and the historic Bozeman Trail. Most areas that provide recreational activities occur in the western portion of the Project Area, near the foothills of the Bighorn Mountains, and in the Powder River Breaks.

Recreational Use

Recreational use of the Project Area is limited, as more than 75 percent of the land is privately owned. Opportunities for dispersed recreation exist on federal and state lands throughout the Project Area. There are few developed recreational sites or facilities within special management areas on federal lands in the Project Area. Developed recreational facilities such as campgrounds are generally limited to private lands in or near to larger communities in the Project Area, and to state historical sites located in the western part of the Project Area. Communities in the Project Area, including Sheridan, Gillette, Wright, Buffalo, and Kaycee, provide a variety of municipal and private recreational facilities, including golf courses, rodeo grounds, ball parks, and swimming pools.

Dispersed Recreation

Dispersed recreational opportunities in the Project Area include hunting, fishing, sightseeing, off-road vehicle (ORV) use, and camping. Hunting is a major recrea-

tion use of state and federal lands in the Project Area. Various big game and upland game bird species are hunted in the region. Big game species include deer, elk, and pronghorn. Game birds hunted in the Project Area include wild turkey, sage grouse, sharp-tailed grouse, Hungarian partridge, chukar partridge, and ring-necked pheasant.

Public lands managed by BLM's Buffalo and Casper Field Offices provide diverse opportunities for recreation, including hunting, fishing, off-road vehicle (ORV) use, sightseeing, and wildlife observation. Public lands generally provide dispersed recreational uses in the Project Area. Some developed recreational facilities occur in special management areas, including Recreation Areas. Public lands support about three percent of the recreational use in the Buffalo Field Office area. While opportunities are available on BLM lands throughout the Project Area, the majority of dispersed recreational uses occur in the western part of the Project Area, including the South Big Horns Area, and along the Powder River. Public lands in much of the Project Area consists of small, isolated tracts of land managed by the BLM that are too small to provide a quality recreational experience. Larger parcels of public lands occur in the southwest part of Johnson County, and along the Powder River. Public lands are accessible via public roads and/or across private land that requires landowner permission.

Recreational use of public lands in the Project Area has increased substantially over the past two decades, and is expected to continue to increase by about five percent every five years for most recreational activities. Visitation to BLM and non-BLM lands in the Buffalo Field Office area, which includes most of the Project Area, is summarized in Table 3–58. Total visitor use by residents and non-resident visitors in 1980 was 730,000 visitor days. The total visitor days of 1,881,763 estimated for 1990 was more than quadruple the 1980 visitor days.

Table 3–58 Recreation Visitor Days in the Buffalo Field Office Area for 1990

	Resident Visitors			Nonresident Visitors			Total Visitor Days		
Type of Visitor Use	Non BLM	BLM	Total	Non BLM	BLM	Total	Non BLM	BLM	Total
Consumptive									
Antelope	4,503	261	4,764	12,263	837	13,100	16,766	1,098	17,864
Deer	49,195	3,042	52,237	39,980	3,861	43,841	89,175	6,903	96,078
Elk	102,421	2,139	104,560	12,449	272	12,721	114,870	2,411	117,281
Small Game	8,000	200	8,200	400	100	500	8,400	300	8,700
Fishing	300,000	3,000	303,000	75,000	1,000	76,000	375,000	4,000	379,000
Total	464,119	8,642	472,761	140,092	6,070	146,162	604,211	14,712	618,923
Nonconsumptive	578,000	15,440	593,440	652,000	17,400	669,400	1,230,00	32,840	1,262,840
Total Visitor Use	1,042,119	24,082	1,066,201	792,092	23,470	815,562	1,834,211	47,552	1,881,763

Source: BLM 2001

The WGFD manages big game populations in big game management units. The Project Area contains all or part of 18 antelope game units, 22 deer (white-tail and mule) game units, and 9 elk game units. The majority of hunting that occurs in antelope and deer hunting units is non-resident hunting. Table 3–59 summarizes the number of participating hunters, total hunter days, and non-resident hunters for big game management units in the Project Area.

Table 3–59 Big Game Hunting in the Powder River Basin Project Area, 2000

Game Unit	Active Hunters	Total Harvest	Hunter Success	Hunter Days	Non-Resident Hunters	Percent Non-Resident Hunters
Antelope	6,877	6,168	89.7%	19,128	5,272	76.7%
Deer	14,680	8,936	60.9%	49,811	7,781	53.0%
Elk	5,934	1,688	28.4%	39,328	981	16.5%

Source: WGFD 2001

Fishing is a popular year-round activity with residents of the Project Area. Bodies of water that are fished within the Project Area are summarized in Table 3–60.

Table 3–60 Fishing Areas in the Powder River Basin Project Area

Sub-Watershed	Water Body	Fish species
Middle Fork Powder River	Beartrap Creek	Brook, Rainbow
	Blue Creek	Brown, Brook, Rainbow
	Dull Knife Reservoir	Brown, Rainbow
	Powder River, Middle Fork	Brown
	Powder River, North Fork	Brown, Rainbow
Crazy Woman	Crazy Woman Creek	Brown, Brook, Rainbow
	Doyle Creek	Brown, Brook
Clear Creek	Clear Creek	Brown, Rainbow
	Lake de Smet	Brown, Rainbow
	North Piney Creek	Brook, Rainbow
Upper Belle Fourche	Gillette Lake	Rainbow

Source: WGFD 2000

Developed Recreation Areas and Recreation Use Sites

Project Area counties include several special recreation management areas on public and private lands. Recreation sites on public lands within each sub-watershed are summarized in Table 3–61. Connor Battlefield State Historic Site and Trail End State Historic Site are in western Sheridan County, near the city of Sheridan. Fort Phil Kearney state Historic Site is in west Johnson County between the cities of Sheridan and Buffalo. Recreational activities available in the Connor Battlefield site include camping and fishing. The Trail End and Fort Phil Kearney sites feature museums and tours. Limited developed recreation facilities are also located in special management areas on BLM-administered public lands.

Visits to the Historic Sites in the years between 1994 and 1998 are characterized by annual increases and decreases, as shown in Table 3–62. These fluctuations are not related to population changes in the counties, which have steadily increased, with the exception on Sheridan County (see Socioeconomic Section). Declines in visits to the parks probably result from ongoing renovation and construction.

There are two scenic byways in the western part of the Project Area that provide access to the Bighorn Mountains. The Bighorn Scenic Byway is on U.S. Route

14 west of Ranchester. The Cloud Peak Skyway is on U.S Route 16 west of Buffalo.

Table 3–61 Recreational Sites in the Powder River Basin Sub-watersheds

Sub-Watershed	Recreation Site	Managing Agency
Little Bighorn River	none	
Upper Tongue River	Amsden Creek Winter Game Refuge	Wyoming Game and Fish Dept.
	Connor Battlefield	Wyoming State Parks and Historical Resources
	Trail End State Historical Site	Wyoming State Parks and Historical Resources
	Cloud Peak Skyway (Wyoming State Scenic Byway)	Wyoming Department of Transportation
	Bozeman Trail	na[1]
Middle Fork Powder River	Middle Fork Recreation Area	BLM – Buffalo Field Office
	Ed O. Taylor Wildlife Habitat Management Area	BLM – Buffalo Field Office
	Gardner Wilderness Study Area	BLM – Buffalo Field Office
	North Fork Wilderness Study Area	BLM – Buffalo Field Office
	Outlaw Cave Recreation Site	BLM – Buffalo Field Office
	Dull Knife Battlefield	Wyoming State Parks and Historical Resources
	Bozeman Trail	na
North Fork Powder River	na	
Upper Powder River	Fortification Creek SMA and WSA	BLM – Buffalo Field Office
	Cantonment Reno	BLM – Buffalo Field Office
	Bozeman Trail	na
South Fork Powder River	na	
Salt Creek	Bozeman Trail	na
Crazy Woman Creek	Dry Creek Petrified Tree Environmental Education Area	BLM – Buffalo Field Office
	Bozeman Trail	na
Clear Creek	Bud Love Wildlife Habitat Management Area	Wyoming Game and Fish Dept.
	Ft. Phil Kearny State Historical Site	Wyoming State Parks and Historical Resources
	Mosier Gulch Recreation Area	BLM – Buffalo Field Office
	Big Horn Scenic Byway (Wyoming State Scenic Byway)	Wyoming Department of Transportation
	Bozeman Trail	na
Middle Powder River	na	
Little Powder River	Weston Hills Recreation Area	BLM – Buffalo Field Office
Little Missouri River	na	
Antelope Creek	Bozeman Trail	na
Dry Fork Cheyenne River	Bozeman Trail	na
Upper Cheyenne River	na	
Lightening Creek	na	
Upper Belle Fourche River	na	
Middle N. Platte Casper	Bozeman Trail	na

Note:
1. na = not applicable
Source: BLM 1984, 2001; National Scenic Byways Program 2001; WDSP&HS 2001

BLM

Several developed recreational sites and areas occur on BLM lands administered by the Buffalo Field Office, as summarized on Table 3–61. There were no developed recreation sites identified on BLM lands administered by the Casper Field Office within the Project Area. The South Big Horns Area is located in the

southwest quarter of Johnson County, primarily within the Middle Fork Powder River sub-watershed. The area provides sensitive and unique resource values, including fisheries, cultural, wildlife, wilderness, and scenery. Special management areas that provide recreational opportunities within the South Big Horns Area include Middle Fork Recreation Area, the Red Wall/Hole-in-the-Wall area, Outlaw Cave Recreation Site (or Cultural Area), Dull Knife Battlefield site, and the Gardner Mountain and North Fork WSAs.

Table 3–62 State Historic Site Visitors: 1994–1998

Historic Site	1994	1995	1996	1997	1998
Connor Battlefield	23,694	18,592	18,926	18,670	15,379
Fort Phil Kearney	27,068	25,167	23,136	22,657	22,128
Trail End	16,584	12,247	16,828	18,004	19,377

Source: Wyoming Division of Economic Analysis 1999

The Middle Fork Recreation Area covers approximately 48,400 acres within the South Big Horns Area along the Middle Fork of the Powder River. The area contains a variety of outstanding natural resources, and is protected from mineral entry because it has unique visual qualities, wildlife habitat, fisheries, and general outdoor recreational qualities. The state of Wyoming has rated the Middle Fork of the Powder River as a Class I trout fishery that is of national importance. The Outlaw Cave Recreation Site, located along the Middle Fork of the Powder River in the Middle Fork Recreation Area, is an important historical site that provides camping, fishing, hiking, and other dispersed recreational activities.

The Dry Creek Petrified Tree Environmental Education Area, located near the town of Buffalo, has been designated as an outstanding natural area. The area contains a parking road, picnic table, and interpretive facilities.

Three WSAs provide primitive, undeveloped types of recreation. There is no public access to the North Fork and Fortification Creek WSAs. Public access to Gardner Mountain WSA is difficult because of the scattered land ownership.

There are two Recreation Areas on BLM-administered public lands in the Project Area. The Mosier Gulch Recreation Area (RA), is west of Buffalo on U.S. Highway 16. The RA includes a picnic area. The RA provides off-highway vehicle use of designated roads and a loop trail open to foot, horse, mountain bike, and ATV use. Two additional loop trails that also will provide these uses may be constructed in the RA. The Weston Hills RA is located in the eastern part of the Project Area, adjacent to a portion of the TBNG. The RA provides hunting and dispersed camping recreational opportunities. A two-mile ATV trail is open October 16 through September 14.

The Bozeman Trail is a historic transportation corridor that was used by historic Indian tribes, trappers and traders, exploration expeditions, American emigrants, the military, and settlers. There are several historical sites associated with the Bozeman Trail that provide recreational opportunities. Interpretive programs and historic sites along the trail include Fort Phil Kearny, Cantonment Reno, and the Connor Battlefield. The trail originates near Fort Laramie, south of the Project

Area, and runs through public and private lands along the eastern side of the Big Horn Mountains through the Project Area into Montana.

Approximately 798,848 acres of public land in Johnson, Sheridan, and Campbell counties has been inventoried and designated as open, limited, or closed to ORV use. Most ORV use in the counties is limited to existing roads and vehicle routes.

Forest Service

The TBNG provides a variety of wildland recreational opportunities to local residents, including many who are employed in mineral industries. Nearly all of the TBNG is open to use by ORVs. The area provides hunting opportunities for residents and non-residents, primarily big game species such as antelope and deer. Shooting restrictions have recently been implemented on the TBNG for the purpose of protecting special biological community associated with the future reintroduction of the endangered black-footed ferret.

Recreation Planning

BLM

The goals of recreation management for all BLM lands in the Project Area are to provide outdoor recreational opportunities on BLM-administered public land while providing for resource protection, visitor services, and the health and safety of public land visitors.

The BLM has also developed a management objective for special management areas within the Project Area, including the South Big Horns Area, the Dry Creek Petrified Tree Environmental Education Area, the Fortification Creek Area, the Weston Hill Recreation Area, and the Mosier Gulch Recreation Area. The management objective for recreation in these areas is to ensure continued public use and enjoyment of recreation activities while protecting and enhancing natural and cultural values; improve opportunities for high quality outdoor recreation; and, improve visitor services related to safety, information, interpretation, and facility development and maintenance.

In order to protect the sensitive and unique resource values of the South Big Horns Area, surface disturbance or occupancy is prohibited in the Red Wall/Hole-in-the-Wall area and within ½-mile of the rim of the Middle Fork Canyon. Goals for the two WSAs in the Area include preserving the existing wilderness characteristics of the WSAs and not allowing activity that would impair the suitability of the WSAs for preservation as wilderness.

Management decisions for the Dry Creek Petrified Tree Environmental Education Area are to preserve the area near its natural state, prevent or slow down deterioration of the petrified trees, and inform the visitor about the area. Surface disturbance or occupancy is prohibited within ½-mile of the site unless waived by the authorized officer.

Management objectives specific to the Fortification Creek Area, which includes the Fortification Creek WSA, are to allow orderly development of mineral re-

sources while protecting wildlife habitat and sub-watershed areas, and maintaining wilderness values. No Surface Occupancy is allowed in elk calving areas, and a seasonal timing limitation is applied to elk wintering areas.

Public lands managed by the Casper Field Office are in three Resource Management Units; (RMU) 6, 11, and 14. The RMUs are within the Middle North Platte River, Dry Fork Cheyenne, and Lightning Creek sub-watersheds. There are no developed recreation sites on public lands administered by the Casper Field Office in the Project Area. Recreational activities consist of dispersed activities such as hunting and ORV use. Recreation management for each RMU is described below:

- RMU 6 (Casper Sand Dunes) – The RMU is managed as an extensive recreation management unit where dispersed recreation would be encouraged in areas where soil and sub-watershed values permit. ORV designations would limit travel to designated roads and vehicle routes on public land, except during the fall hunting season, when travel would be permitted on existing roads and vehicle routes. Recreation management is minimal, with emphasis on monitoring, use supervision, and enforcement to resolve user conflicts and provide resource protection.
- RMU 11 (Ross) – The RMU is managed as an extensive recreation management unit where dispersed recreation would be encouraged and where visitors would have freedom of recreational choice with minimal regulatory constraint. ORV use is limited to existing roads and vehicle routes on all public lands within the unit.
- RMU 14 (Remaining Platte River Resource Area) – RMU 14 comprises all lands managed by the Casper Field Office not included in the other RMUs, and contains portions of the Thunder Basin National Grassland. It is managed as an extensive recreation management unit where dispersed recreation would be encouraged and where visitors would have freedom of recreational choice with minimal regulatory constraint. ORV use is limited to existing roads and vehicle routes for those Project Area on all public lands within the unit.

Forest Service – Thunder Basin National Grassland

The Medicine Bow-Routt National Forest has developed a Proposed LRMP for the TBNG (1999). Under the Preferred Alternative 3, TBNG lands within the Project Area are within seven management areas. Each management area is managed for a particular emphasis or theme. The standards and guidelines for recreation in each management area is summarized in Table 3–63.

National Forest System lands are inventoried and mapped by Recreation Opportunity Spectrum (ROS) class to identify the opportunities for recreation activities that occur on National Forest System lands. The ROS system is a continuum divided into six classes ranging from Primitive to Urban. All of the TBMG lands in the Project Area have been inventoried with the Semi-Primitive Motorized class (Forest Service 1986).

Table 3–63 Recreation Standards and Guidelines for TBNG Management Areas in the Project Area

Management Area		Standards & Guidelines
3.63	Black-Footed Ferret Reintroduction Habitat	-Prohibit shooting in prairie dog colonies unless needed to help reduce unwanted colonization of adjoining lands. (Guideline) -Work with Animal and Plant Health Inspection Service and state agencies to prohibit the use of leg-hold traps without pan-tension devices for predator control and fur harvest on National Forest System lands in this management area. (Guideline)
3.65	Rangelands with Diverse Natural-Appearing Landscapes	na
3.68	Big Game Range	Permit recreation facilities needed to support summer recreational activities, but close them during period when big game are present in concentrated numbers. (Guideline)
4.32	Dispersed Recreation: High Use	-Allow uses and activities (e.g., grazing, mineral leasing) only if they do not degrade the characteristics for which the area was identified. (Guideline) -Do not salt or supplement feed within ¼-mile of designated roads. (Guideline)
5.12	General Forest and Rangelands: Range Vegetation Emphasis	na
6.1	Rangeland with Broad Resource Emphasis	na
8.4	Mineral Production and Development	na

The Semi-Primitive Motorized class is characterized by a predominantly unmodified natural environment in a location that provides good to moderate isolation from sights and sounds of man except for facilities and travel routes sufficient to support motorized recreational travel opportunities that present at least moderate challenge, risk, and a high degree of skill testing.

State

The mission of Wyoming State Parks and Historic Sites is to provide quality recreational and cultural land and opportunities, and to be responsible stewards of these resources. The Wyoming Department of State Parks & Cultural Resources has the authority to promulgate rules and regulations governing state parks. These rules include and cover the following areas: (a) Conservation of peace and good order within each park; (b) Preservation of state property; and (c) Promotion of well being for park visitors and residents. There is no provision in the rules and regulations governing the development of mineral or other industrial developments within state parks.

Counties

The Sheridan County Growth Management Plan (Sheridan Plan), a comprehensive master plan for the city of Sheridan and all of Sheridan County was prepared in May of 2001. One of the primary themes identified in the Sheridan Plan is to maintain a community character that preserves the quality of life, values and tra-

ditions of the area. The goals and the associated implementation strategies that relate to mineral development for achieving this theme are described below.

Goal E. Enhance Recreational Opportunities

1.E.1 Protect open spaces, flood channels, and waterways throughout Sheridan County by planning for an integrated open space network compatible with existing trails or pathway plans, open space plans, or flood management plans. As subdivisions and other development are reviewed, achieve over time a comprehensive open space network.

1.E.2 As part of subdivision review, encourage the development of the Sheridan Pathways project and the development of a trail along Little Goose Creek.

1.E.3 Encourage recreation activities in Sheridan County.

1.E.5 Support efforts to identify and obtain open space in the county. The Sheridan County Planner should investigate and pursue mechanisms that can enable open space to be preserved. Open space, to be meaningful and usable, should be lands that:

- Are adjacent to existing open space or public lands;
- Have special scenic or environmental qualities;
- Enable the preservation of scenic, recreational, or environmental resources, and;
- Include pathways, bikeways, trails, golf courses, recreational areas, parks, historic areas, and conservation easements. With the long-term goal of eventual connection of various units of open space acquired through the subdivision process, an open space network can be created.

The City of Gillette and Campbell County have jointly prepared a Comprehensive Planning Program (Program), last updated March 1994. The Program identifies parks and recreation planning as an essential element determining the character and quality of an environment. Existing parks and their facilities that are maintained by the Campbell County Parks and Recreation Department are listed in the Program document. Existing facilities are located primarily within or in the vicinity of the cities of Gillette and Wright. The Savageton Community Park is located ¼-mile south of Savageton in southwestern Campbell County.

The General Land Use Plan for Converse County (Converse Plan) was developed in August of 1978. According to the Converse Plan, Objective #3 for Rural Centers is to provide for those recreational activities as required by the increase of population. The policy to achieve this objective is to have recreational developments only in those areas with adequate access and in conformance with the Land Use Plan and Converse County Subdivision and Development Regulations. Converse County is currently updating the Land Use Plan.

Johnson County is currently developing a land use plan. There are no goals for the management of recreation resources in the county.

Wild and Scenic Rivers

The BLM has identified public lands along four waterway segments that were determined to meet the eligibility criteria for Wild and Scenic River (WSR) designation. The waterway review segments that were evaluated for eligibility criteria are along the Beartrap Creek, the Middle Fork of the Powder River, the Powder River at Cantonment Reno, and the North Fork of the Powder River review segments. The Beartrap Creek, North Fork of the Powder River, and the Powder River at Cantonment Reno were found to be not suitable for Wild and Scenic Rivers status primarily because of private land use and public access conflicts, or because they would not be worthy additions to the system. The Middle Fork of the Powder River was determined to be a worthy addition to the Wild and Scenic River System. The eligibility analyses for the four waterway review segments are included in the attachments A, B, and C of BLM's Approved Resource Management Plan for the BFO (2001). The analysis for the Middle Fork of the Powder River is summarized on Table 3–64.

Table 3–64 Middle Fork of the Powder River Waterway Segments Eligible for WSR Designation in the Powder River Project Area

Reviewed Waterway Segment	Length of segment across BLM Land Parcel	Outstandingly Remarkable Values	Tentative Classification
sec. 25, 26; T42N, R86W	1.2	Fisheries; Class 1 fishery	Recreational
W½ NW¼ sec. 30; T42N, R85W	0.25	Fisheries; Class 1 fishery	Wild
sec. 19-23, 28-30; T42N, R85W	3.25	Scenic, Fisheries, Cultural, Wildlife, Recreational; Class 1 fishery. Native American cultural sites. Recreational hiking and cultural interpretation opportunities.	Wild
sec. 22, 23; T42N, R85W	1.0	Scenic, Fisheries, Cultural, Wildlife, Recreational. Class 1 fishery. Native American cultural sites. Recreational hiking and cultural interpretation opportunities.	Wild
sec. 19-22, 30; T42N, R84W and sec. 24; T42N, R85W	5.0	Scenic, Fisheries, Wildlife, Recreational, Historic, Cultural; Spectacular, primitive canyon. Nationally and regionally historic Outlaw Cave. Native American rock art and shelter sites. Class 1 fishery. Recreational hiking and cultural interpretation opportunities.	Wild

Source: BLM 2001

Noise

Noise is generally described as unwanted sound. Discussions of environmental noise do not focus on pure tones because commonly heard sounds have complex frequency and pressure characteristics. Accordingly, sound measurement equipment has been designed to account for the sensitivity of human hearing to different frequencies. Correction factors for adjusting actual sound pressure levels to correspond with human hearing have been determined experimentally. For measuring noise in ordinary environments, A-Weighted correction factors are em-

ployed. The filter de-emphasizes the very low and very high frequencies of sound in a manner similar to the response of the human ear. Therefore, the A-weighted decibel (dBA) is a good correlation to a human's subjective reaction to noise.

The following discussion sets a basis of familiarity with known and common noise levels. A quiet whisper at five feet is 20 dBA; a residential area at night is 40 dBA; a residential area during the day is 50 dBA; a large and busy department store is 60 dBA; rush hour traffic at 100 feet from the road is 60-65 dBA; Interstate traffic at 200 feet is 65 dBA; a heavy truck at 50 feet is 75 dBA; and a typical construction site is 80 dBA. At the upper end of the noise spectrum, a jet takeoff at 200 feet is 120 dBA (Harris 1991).

The dBA measurement is on a logarithmic scale. The apparent increase in "loudness" doubles for every 10 dBA increase in noise (Bell 1982). Taking a baseline noise level of 50 dBA in a daytime residential area, noise of 60 dBA would be twice as loud, 70 dBA would be four times as loud, and 80 dBA would be eight times as loud.

The land uses in the Project Area range from sparsely populated rural regions to more densely populated urbanized areas to industrial areas, such as coal mining and CBM operations. Major sources of noise are towns; industrial facilities; major roadways, such as Interstate 90; railroad corridors; and frequent high winds. Background noise surveys have not been conducted in the area. However, noise in rural areas away from industrial facilities and transportation corridors is generally 30 to 40 dBA when the winds speeds are low. Levels of noise close to industrial facilities and transportation corridors are likely to be in the range of 50 to 70 dBA depending on the proximity to these sources. The most significant noise from CBM operations results from the operation of compressor stations that use multiple engines to move natural gas from central gathering facilities and along high-pressure transmission pipelines. Noise from these compressor stations has been estimated has been estimated to be 55 dBA at 600 feet from the compressor station (BLM 2000).

Socioeconomics

The Project Area encompasses all or portions of Converse, Campbell, Johnson, and Sheridan counties in Wyoming. It also includes four incorporated municipalities: Gillette, Wright, Sheridan, and Buffalo. Gillette is the county seat and the largest incorporated city in Campbell County. Wright is in southern Campbell County. Sheridan is the county seat of Sheridan County and Buffalo is the county seat of Johnson County. These four counties are the primary counties that potentially would experience socioeconomic impacts. However, socioeconomics, with respect to Environmental Justice, will also be addressed herein for four Counties in Montana, just north of the Project Area.

Population

The 2000 population in the Project Area is: Converse County, estimated at 12,052; Campbell County, estimated at 33,698; Johnson County, estimated at 7,075; and Sheridan County, estimated at 26,560. The total population is 79,385

for these four counties combined, which make up 16 percent of the population in State of Wyoming. Table 3–65 summarizes population growth and projections of population growth between 1980 and 2002.

Table 3–65 Population Estimates in Campbell, Converse, Johnson, Sheridan Counties and Wyoming

Location	1980	1990	1996	1997	2000
Campbell County	24,367	29,370	31,931	32,071	33,698
Gillette	14,545	17,545	21,585	19,289	19,646
Wright	Na	1,117	1,385	1,347	1,347
Converse County	14,069	11,128	12,125	12,295	12,052
Douglas	Na	5,076	5530	5,634	5,288
Glenrock	Na	2,153	2329	2,367	2,231
Johnson County	6,700	6,145	6,717	6,796	7,075
Buffalo	Na	3,302	na	na	3,900
Kaycee	Na	260	303	308	307
Sheridan County	25,048	23,562	25,203	25,199	26,560
Sheridan	Na	13,900	na	na	15,804
State of Wyoming	469,551	453,588	480,085	480,031	493,782

Source: U.S. Census Bureau 1998a, Wyoming Division of Economic Analysis 1997a.

Growth in these counties has also been prevalent over the last ten years. According to the U.S. Census Bureau, the Counties within the Project Area have undergone 12.7 percent growth between 1990 and 2000. Johnson County had a 15.1 percent growth in that time period, ahead of Campbell (14.7 percent), Sheridan (12.7 percent) and Converse (8.3 percent) Counties.

Between 2000 and 2008, it is projected that the counties within the Project Area will experience the following population increases: Campbell County will increase by 4 percent; Converse County will increase by 8 percent; Johnson County will increase by 4 percent; and Sheridan County will decrease by 0.5 percent. All counties within the Project Area, with the exception of Sheridan County, will have higher population increases than the projected population increase for the State of Wyoming of 2 percent. Projected population within the Project Area is provided in Table 3–66.

Table 3–66 Projected Populations in Campbell, Converse, Johnson, Sheridan Counties and Wyoming

Location	2001	2002	2003	2004	2005	2006	2007	2008
Campbell County	33,210	33,490	33,780	34,080	34,370	34,670	34,970	35,270
Gillette	19,970	20,075	20,249	20,429	20,603	20,783	20,962	21,142
Wright	1,384	1,396	1,408	1,420	1,432	1,445	1,457	1,470
Converse County	12,550	12,640	12,720	12,810	12,900	12,990	13,080	13,170
Douglas	5,725	5,766	5,803	5,844	5,885	5,926	5,967	6,008
Glenrock	24,00	2,428	2,444	2,461	2,478	2,496	2,513	2,530
Johnson County	6,970	7,030	7,090	7,150	7,210	7,270	7,330	7,390
Buffalo	3,741	3,773	3,806	3,838	3,870	3,902	3,934	3,967
Sheridan County	25,480	25,600	25,740	25,870	26,010	26,140	26,270	26,410
Sheridan	14,864	14,934	15,016	15,092	15,173	15,249	15,325	15,407
State of Wyoming	486,240	488,480	490,810	493,230	495,630	498,020	500,380	502,780

Source: Wyoming Division of Economic Analysis 1997a.

Employment

The annual average labor force for the Project Area consists of 37,337 employees and the overall unemployment rate for the Project Area is 6.7 percent, 0.4 percent higher than the unemployment rate for the State of Wyoming. Specific labor force estimates, by County and for the State of Wyoming, are provided in Table 3–67.

Table 3–67 Labor Force Estimates

Location	Labor Force	Employment	Unemployment	Unemployment Rate (percent)
Campbell County	18,520	17,541	979	5.3
Converse County	6,508	6,105	403	6.2
Johnson County	3,750	3,579	171	4.6
Sheridan County	13,364	12,655	709	5.3
State of Wyoming	239,000	224,000	15,000	6.3

Source: Wyoming Department of Employment 1997a.

Employment Sectors and Wages

Wyoming Department of Employment (WDOE), Employment Resources Division, records describe the employment sectors in the affected Counties. The 1997 Campbell County employment statistics indicated that the primary employment sectors were dominated by Mining (consists of coal mining, oil and gas extraction, crude, petroleum-natural gas, oil and gas field service and nonmetalic minerals as defined by the US Bureau of Labor Statistics), Local Government, Tetail Trade and Services. Specifically, 25 percent of the income was from Mining, 17 percent was from Local Government, 17 percent was from Retail Trade, and 15 percent was from Services. Agriculture accounted for 1 percent of the employment in the County.

The 1997 Converse County employment statistics indicated that the primary employment sectors were dominated by Mining, Local Government, Retail Trade and Services. Specifically, 21 percent of the income was from Mining, 29 percent was from Local Government, 25 percent was from Retail Trade, and 15 percent was from Services. Agriculture accounted for 2 percent of the employment in the County.

The 1997 Johnson County employment statistics indicated that the primary employment sectors were dominated by Local Government, Retail Trade and Services. Specifically, 22 percent was from Local Government, 24 percent was from Retail Trade, 18 percent was from Services. Agriculture accounted for 2 percent of the employment in the County and, unlike Converse and Campbell Counties, area only 5 percent of the income was from Mining.

The 1997 Sheridan County employment statistics indicated that the primary employment sectors were dominated by Local Government, Retail Trade and Services. Specifically, 18 percent was from Local Government, 22 percent was from Retail Trade, and 25 percent was from Services. Agriculture accounted for less

than 1 percent of the employment in the County and, unlike Converse and Campbell Counties, less than 1 percent of the income was from Mining.

Table 3–68 also identifies the Income and Earnings by industry for all four Counties. Mining consistently averages to be one of the highest paying industries, as does Finance, Insurance, Real and Estate (FIRE) and Transportation, Communication and Utilities (TCU). Employment in Agriculture and Retail Trade, tend to have the lowest earnings in all four Counties.

Table 3–68 Employment Income and Earnings by Industry

	Average Annual Wage				
Industry	Campbell County	Converse County	Johnson County	Sheridan County	State of Wyoming
Agriculture	13,976	14,625	18,882	14,886	16,161
Construction	27,655	27,957	17,730	20,738	25,509
Finance, Insurance, Real Estate	22,704	20,414	24,284	33,695	28,954
Manufacturing	33,534	19,746	18,358	25,147	30,798
Mining	52,702	45,018	35,188	41,514	47,053
Public Administration	28,431	26, 172	26,600	30,252	27,863
Trade-Retail	13,447	10,234	10,703	12,196	12,884
Trade-Wholesale	35,988	12,995	17,480	25,704	29,133
Services & Misc.	20,276	14,047	15,511	18,197	18,712
Transportation, Communication & Utilities	30,884	48,433	24,527	25,547	32,283
Total (average)	30,420	24,682	18,517	20,920	26,935

Source: Wyoming Department of Employment, Employment Resources Division, 1997a and 1997b.

The median household income in Converse, Johnson and Sheridan counties increased between 1969 to 1997 by an average of 64 percent. The median household income in Campbell County decreased by 3 percent between 1969 and 1997. All four Counties experienced a peak in median household income in 1979. Campbell County median household incomes were higher than the State of Wyoming average, while Johnson and Sheridan Counties experienced lower median household income than the State of Wyoming average. Converse County also experienced higher median household income (Table 3–69) than the State of Wyoming, with the exception of 1969, when the average was slightly lower.

Table 3–69 Median Household Income

Location	1969	1979	1989	1997
Campbell County	34,103	43,668	37,055	33,197
Converse County	23,365	38,026	27,713	37,978
Johnson County	21,313	27,659	22,157	31,832
Sheridan County	20,699	30,348	24,772	33,000
State of Wyoming	25,288	33,503	27,096	33,197

Source: Wyoming Division of Economic Analysis 1997b and the US Census Bureau 2000b.

Housing

The property values within each community could potentially be impacted by an influx in population. Currently, home values within the Project Area range from $76,000 to $130,000 for an existing three bedroom and $120,000 to $160,000 for a new three bedroom (Table 3–70).

Table 3–70 Property Valuation

	Cost of Individual Homes in 2001	
Location	Average New Three Bedroom	Average Existing Three Bedroom
Campbell County		
Gillette	$132,560	$106,110
Wright	$120,000	$76,531
Converse County	$132,000	$106,111
Johnson County		
Buffalo	$160,000	$130,000
Sheridan County		
Sheridan	$107,000[a]	NA

Note:
a. 1999 data only, in 2001 the average cost of three bedroom in rural areas was 125,000.
Sources: Buffalo Chamber of Commerce 2001, Campbell County Chamber of Commerce 2001.

Housing costs within the Project Area vary considerably. Of all counties within the Project Area, Campbell County has experienced some of the higher cost for real estate. According to the Campbell County Board of Realtors, residential property in Gillette, 71 percent of homes sold during the 2Q 2000- 1Q 2001 were priced less than $120,000 (Campbell County 2001). In the same time period, 94 percent of residential properties in Wright priced at $100,000 or less. However, the greatest number of sales occurred in the $60,000- $70,000 range. No properties in this price range were sold following 2Q 2000.

The majority of the available housing in the Project Area a located in the communities of Gillette, Wright, Sheridan and Buffalo. There were a total of 35,037 housing units in the Project Area in 2000. In 1990, the average housing availability rate for the Project Area was 23.3 percent. Table 3–71 identifies the Housing Units and Availability for all four Counties.

According to the Campbell County Housing Needs Assessment, it is estimated that in 2001, 98 housing units will be rentals and 92 housing units will be purchased as a result of Coal Bed Methane Development and Production. It is also estimated that county wide, as a result of all industries, 449 housing units will be rentals and 861 housing units will be purchased housing. Current projections from this study indicated that rental demand associated with Coal Bed Methane continue to increase (249 rentals) through 2008, and will slowly decrease thereafter (study limited to 2020). Projected purchase demand will continue to increase (465 purchases) through 2009, and will slowly decrease thereafter (study limited to 2020).

Table 3–71 Housing Units and Availability

Location	Housing Units (count) in 2000	Housing Availability in 1990
Campbell County	13,288	15.8%
Gillette	7,31	
Wright	544	
Converse County	5,669	29.4%
Douglas	2,385	
Glenrock	1,131	
Johnson County	3,503	29.8%
Buffalo	1,842	
Sheridan County	12,577	18.3%
Sheridan	7,413	

Source: U.S. Census Bureau 1990 and 2000c.

Housing costs range from $353 per month, in Converse County to $432 per month, in Campbell County, for a 2-bedroom apartment. The average 2 to 3 bedroom house ranges from $436 per month, in Converse County, to $632 per month in Campbell County. In all housing categories and all counties, mobile homes tend to provide the most economical housing value. Overall, housing costs are highest in Campbell County and lowest in Converse County. Housing Costs are shown in Table 3–72.

Table 3–72 Monthly Housing Costs for the 4th Quarter of 2000

	Housing Cost by County per month			
Housing Cost (4qtr 2000):	Campbell	Converse	Johnson	Sheridan
2-bedroom Apartment	$432	$353	$396	$405
Single-wide mobile home w/ water	$197	$115	$137	$175
2/3 bedroom house	$632	$436	$569	$580
Monthly mobile home rent including lot rent	$483	$324	$488	$447

Source: Wyoming Division of Economic Analysis, 2000a.

Community and Government Services

Natural gas and CBM exploration and resource development activities have the potential to affect existing community facilities and infrastructure. The use of, or connection to existing infrastructure including impacts population, which subsequently can affect local community services such as schools, law enforcement, or medical facilities. The following paragraphs present a baseline description of these facilities and services

Water and Wastewater Systems, and Solid Waste Disposal

Generally, each county relies on the municipal population centers to provide water, waste water systems, and solid waste disposal. In some instances, the counties contribute financially to the municipal infrastructure. Communities, which are not incorporated into the city water and septic system, generally provide for themselves with water wells and septic tanks on their personal property. In

Campbell County, water, waste water systems and solid waste disposal are operated by the city of Gillette. In Converse County the water, waste water systems and solid waste disposal are operated by the communities of Glenrock and Douglas. Glenrock and Douglas each have their own landfill, which the county contributes to financially. In Johnson County the water, waste water systems and solid waste disposal is operated by the City of Buffalo. In Sheridan County the water, waste water systems and solid waste disposal by the City of Sheridan.

Public Schools, Law Enforcement and Fire Protection, Medical Facilities, Community Services

There are 78 Pre Kindergarten through 12th grade public schools in the Project Area. Campbell County operates 22 public schools, Converse County operates 14 public schools, Johnson County operates nine public schools, and Sheridan County operates 24 public schools. Sheridan College, Eastern Wyoming College in Glenrock and Douglas, and University of Wyoming extension services are higher education learning centers within the Project Area.

Law enforcement services within Campbell County are provided by the Campbell County Sheriff's Department. The department consists of 39 sworn officers and 22 patrol officers. Law enforcement services within Converse County are provided by the Converse County Sheriff's Department, which has 9 sworn officers. Law enforcement services within unincorporated Johnson County are provided by the Johnson County Sheriff's Department, which has 14 sworn officers. Kaycee and Buffalo (Johnson County) also have police departments, each with 1 and 13 sworn officers. Law enforcement services within unincorporated Sheridan County are provided by the Sheridan County Sheriff's Department, which has 15 sworn officers. The City of Sheridan Police Department also has 29 sworn officers.

Each County in the Project Area operates a detention center. The Campbell County Detention Facility has 101 beds, the Converse County Detention Facility has 34 beds, the Johnson County Detention Facility has 17 beds and the Sheridan County Detention Facility has 46 beds. According to personnel at the Sheridan County Detention Facility, the presence of CBM development has had a direct impact on the facility. The facility has increased in population in the last year by approximately one third, primarily due to DUI (Driving Under the Influence) arrests and secondarily due to public intoxication by CBM employees (Smith 2001).

Fire protection in Campbell County is provided by the Campbell County fire department, which consists of 13 full time fire fighters and 150 volunteer fire fighters. Fire protection in Converse County is provided by the Campbell County Rural Fire Department, Glenrock Fire Department and Douglas Fire Department, which consists of a total of 125 volunteer fire fighters. Fire protection in Johnson County is provided by the Johnson County Fire Department. Sheridan County has 24 full time fire fighters, employed by the City of Sheridan and aided through a mutual aid agreement, which involvers approximately 50 fire fighters in the surrounding communities of Ranchester, Dayton, Bighorn and Story.

There are six 24-hour emergency service hospitals within the Project Area. The Campbell County Memorial Hospital is a 119-bed community hospital. In Converse County, two hospitals operate, one in Douglas, which has 44 beds, and one in Glenrock. In Johnson County, the hospital has 29 beds. In Sheridan County, the Sheridan County Memorial Hospital has 80 beds. The Veterans Administration Hospital also serves Sheridan County. All the counties in the Project Area have ambulance service, additional medical facilities, and specialized physicians.

A number of social service resources exist within the Project Area, generally sponsored by the cities and counties. The Way Station (Gillette) and the Volunteers of America Homeless Center (City of Sheridan) are homeless shelters in the Project Area. In Johnson County, there are additional social services through the Family Crisis Center and Ministerial Association in Buffalo.

Public Finance

Wyoming is the top coal producing state in the United States. According to the Campbell County Chamber of Commerce more than 90 percent of the coal produced in the State of Wyoming comes from Campbell County (BLM 1999c). Campbell County also produces approximately 25 percent of oil produced in Wyoming each year. Table 3–73 shows the state assessed mineral production valuations for the affected Counties and the State for Wyoming for its 2000 fiscal year, which are based on 1999 production.

Table 3–73 Taxable Valuation of Mineral Production for Fiscal Year 1999 Campbell, Converse, Johnson, and Sheridan Counties

	Taxable Mineral Valuation						
Valuation Source	Coal	Crude and Stripper Oil	Natural Gas	Sand & Gravel	Uranium	Other Minerals[1]	Total Assessed Valuation
Wyoming Valuation ($ million)	1,246	908	1,624	10.9	19.4	275	4,083
Campbell County Valuation ($ million)	976	215	98.9	2.98	1.58	0	1,294
Percent of State's Valuation	79%	24%	6.0%	27%	8.1%	0	32%
Converse County Valuation ($ million)	74.8	64	39.3	0.557	0	.245	186
Percent of State's Valuation	6.0%	6.0%	2.4%	%	0	0.09%	4.6%
Johnson County Valuation ($ million)	0	20.8	1.35	0.808	0.095	0.969	23.4
Percent of State's Valuation	0	2.3%	0.08%	7.0%	0.50%	0.35%	0.56%
Sheridan County Valuation ($ million)	0.897	0.486	0.001	0.420	0	0	1.80
Percent of State's Valuation	0.07%	0.05%	0.001%	3.8%	0	0	0.044%

Note:
1. Includes Bentonite produced in Johnson County and Leonardite produced in Converse County.
Source: Wyoming Department of Revenue 2000

Agriculture, consisting of livestock production and dryland farming also is an important sector of the economic base within the affected Counties. According to Campbell County Economic Development Corporation, livestock population in the County consists primarily of cattle and sheep. Most cropland in Campbell County produces wheat, barley, oats, and hay for fed. Agriculture in Converse, Johnson, and Sheridan counties consists of ranching, crops such as wheat, barley and oats, and irrigated forage crops (BLM 1999c).

The taxable valuation of mineral production provides a significant amount of capital to the governing agencies. According to the Wyoming Department of Revenue, for the fiscal year 1999 through June 30, 2000, 37 percent of State of Wyoming's Taxable Valuation of Minerals Production was from the Project Area. Campbell County accounted for the highest taxable mineral valuation of the State of Wyoming for coal with in the Project Area (79 percent) and also was had the highest taxable mineral valuation of the State of Wyoming for crude and stripper oil (24 percent). Based on the existing tax structure for the State of Wyoming, mineral production creates a significant tax-generating stream. The taxes on production are provided in Table 3–74.

Table 3–74 State of Wyoming Oil and Gas Taxes

Tax	Rate
Severance Tax	6% on normal
Ad Valorem Taxes	6.3 percent (Campbell and Converse Counties in 1999) 6.8 percent (Johnson and Sheridan Counties in 1999)
Wyoming Oil and Gas Tax Variances	Tertiary Oil Production (4%) Renewed Production (1.5% severance tax for 1st 60 month production period); Workover/Recompletion Production (2 percent severance tax for 1st 24 months of production after Workover/Recompletion) New wells drilled (7/1/93-3/31/03) (2% severance tax for 1st 24 months of production up to 60 bbls/day or 6MCF/bbl gas equivalent).
Wyoming Oil and Gas Conservation Tax	0.060 percent
Tribal Severance Tax	8.5 percent on non-stripper oil production and gas production and 4 percent on oil stripper wells (bpd or less)

Source: BLM 2001c.

Quality of Life

Public lands within the Project Area also provide a variety of benefits to adjacent landowners and communities that are much more difficult to quantify than the socioeconomic indicators provided here. These benefits include contributions to a person's quality of life, like scenic view, open space, and opportunities for recreation, habitat for wildlife, range for agriculture, clean air and water. While oil and gas development certainly provides some economic opportunities for residents and communities, such as employment and tax revenues, such development

is perceived by some as detracting from their quality of life. In most cases, this perception is shared by those not directly benefiting from the industry's activities.

Since quality of life is more a matter of personal perspective than a definitive outcome, which BLM can directly affect, BLM will not attempt to quantify quality of life issues nor prescribe a desired outcome. Rather the focus will be on more site-specific factors within the EIS, which might affect the quality of life, like wildlife, agriculture, recreation, air quality, water quality and scenic viewsheds.

Environmental Justice

On February 11, 1994, the President of the United States issued Executive Order 12898 on Environmental Justice in Minority and Low Income Populations. The purpose of the Order is to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects of programs, policies, or activities on minority or low income populations. In the Project Area for this EIS, minority populations include Native American, Hispanic, and low-income Caucasian populations. Large segments of these populations also compose the low- income groups in this area.

Although the Project Area is within Wyoming, socioeconomic impacts, with respect to Environmental Justice, may be felt beyond the Project Area, specifically in four counties (Big Horn, Powder River, Rosebud and Yellowstone) in Montana, which are the home of two Indian Reservations (Crow and Northern Cheyenne). The majority of the Crow Reservation and approximately half of the Northern Cheyenne Indian Reservation are located within Big Horn County Montana. A very small portion of the Crow Indian reservation is located in Yellowstone County Montana and the remaining half of the Northern Cheyenne Indian Reservation occupies approximately one tenth of the Rosebud County Montana.

Because the socioeconomic affects may be felt in these adjacent communities, it is important to evaluate the social composite of these areas as well. Specifically, due to the proximity of the Crow and Northern Cheyenne Indian Reservations, an Environmental Justice analysis is incorporated in this EIS, as the project has the potential to impact these communities. The Crow Reservation is bordered on the south by the State of Wyoming with its northwestern boundary bordered by the city of Billings, Montana's largest metropolitan area. According to the Wyoming-Montana Tribal Leaders Council, approximately 76 percnet of the 9,024 enrolled members live on the Crow Reservation. The total labor force on the Crow Reservation is 1,546. The unemployment rate is 44 percent. The average per capita income is $4,243. Approximately 69.8 percent have a high school diploma and over 6 percent have a Bachelor's Degree or higher (Tribal Leaders Council 2001b).

The Northern Cheyenne Reservation covers 445,000 acres and is bounded on the east by the Tongue River and on the west by the Crow Reservation. The total tribal enrollment is 6,479. Approximately 4,064 Northern Cheyenne live on or near the reservation. The total labor force of the reservation is 1,218 and the un-

employment rate is 31.4 percent. The per capita income is $4,479. Approximately 62 percent of the tribal members have a high school diploma and 5.6 percent have a Bachelor's Degree or higher (Tribal Leaders Council 2001b).

Racial Composite

The Racial Composite of four Counties in Wyoming (Campbell, Converse, Johnson and Sheridan) and four Counties in Montana (Big Horn, Powder River, Rosebud, and Yellowstone) are generally white. As shown in Table 3–75, Big Horn County and Rosebud County, which are occupied by both Indian Reservations, have much higher percentage of American Indians, (32 percent and 60 percent, respectively) than the State of Montana (6.2 percent).

Table 3–75 Racial Composite by County and State for 2000

	Portion of Racial Composite (percent)							
Location	White	Black	Amer. Indian, Eskimo, or Aleut	Asian	Native Hawaiian or Pacific Islander	Some Other Race	Two or More Races	Hispanic Origin
Campbell County	96.1	0.2	0.9	0.3	0.1	1.1	1.3	3.5
Converse County	94.7	0.1	0.9	0.3	0.0	2.5	1.5	5.5
Johnson County	97.0	0.1	0.6	0.1	0.0	0.6	1.6	2.1
Sheridan County	95.9	0.2	1.3	0.4	0.1	0.8	1.3	2.4
State of Wyoming	92.1	0.8	2.2	0.5	0.1	2.5	1.8	6.4
Big Horn County	36.6	0	60.0	0.2	0	0.7	2.8	3.7
Powder River County	97.4	0	1.8	0.1	0	0.2	0.5	0.6
Rosebud County	64.4	0.2	32.4	0.3	0	0.6	2.0	6.0
Yellowstone County	92.8	0.4	3.1	0.5	0.04	1.3	1.8	3.7
State of Montana	90.6	2.9	6.2	0.5	0.05	0.6	1.7	2.0

Source: US Census Bureau 2000c and Wyoming Divion of Economic Analysis 2000.

Population by Age

Population by Age indicates that generally the majority of the population affected by the Proposed Project is between the ages of 25 and 44 years of age. The percentage of the population within the Project Area is consistent of the percentage of the population in the State of Wyoming, with the exception of Power River County, which has 21.9 percent over the age of 65, compared with 13.1 percent for the State of Wyoming. Table 3–76 provides the percentage of the population by age.

Poverty

As shown in Table 3–77 the poverty rates in Converse, Johnson and Sheridan Counties, 12.6 percent, 13 percent and 12.5 percent respectively, are slightly higher than that for the State of Wyoming poverty rate of 12 percent. Campbell County, which has a poverty rate of 7.8, is significantly lower than the poverty rate for the State of Wyoming. The poverty rates in Big Horn, Powder River, Rosebud and Yellowstone Counties do not exceed the Montana poverty rate.

Table 3–76 Percentage of the Total Population by Selected Age Groups by County and State in 1999

Location	0-4 years (percent of population)	5-17 years (percent of population)	18-24 years (percent of population)	25-44 years (percent of population)	45-64 years (percent of population)	65+ years (percent of population)
Campbell County	7.8	24.8	9.7	32.0	20.5	5.2
Converse County	6.5	22.6	8.6	26.6	25.2	10.5
Johnson County	5.0	18.1	8.1	22.6	27.9	18.3
Sheridan County	4.9	18.7	9.0	25.2	26.9	15.3
State of Wyoming	6.3	20.1	11.2	26.5	24.3	11.6
Big Horn	9.3	27.4	10.1	25.3	19.7	8.2
Powder River	5.5	17.8	6.7	21.5	26.6	21.9
Rosebud	7.7	27.3	8.6	28	20.6	7.8
Yellowstone	6.0	18.6	10.3	26.9	25.1	13.1
State of Montana	6.0	19.3	10.1	26.3	25	13.3

Source: U.S. Census Bureau 1999

Table 3–77 Percentage of the Total Population by Poverty Level by County and State for 1997

Location	Poverty Rate
Campbell County	7.8
Converse County	12.6
Johnson County	13.0
Sheridan County	12.5
State of Wyoming	12.0
Big Horn	15.5
Powder River	15.3
Rosebud	15.5
Yellowstone	12.1
State of Montana	15.5

Source: US Census Bureau 1997.

Chapter 4
Environmental Consequences

Chapter 4 — Environmental Consequences

This chapter of the EIS provides an analysis of the effects (environmental consequences) that would result from implementation of the Proposed Action and alternatives. An environmental effect or consequence is defined as a modification or change in the existing environment brought about by the action taken. Effects can be direct, indirect, or cumulative in nature and can be temporary (short term) or permanent (long term). Effects can vary in degree ranging from only a slight discernable change to a drastic change in the environment. For the purpose of this EIS, short-term effects are defined as those that would occur during the construction and drilling/completion phases. Long-term effects are those caused by construction and operations that would remain longer.

The effects analysis evaluated the effects that would occur in the Project Area, regardless of land ownership. However, the BLM and FS' decisions on this Project would only apply to federal lands. The effects reported for non-federal lands may occur regardless of the BLM and FS' decisions. Effects on non-federal lands are included to provide a full disclosure of effects for the complete Project and to support other environmental permitting associated with the Project.

Groundwater

During CBM development, a portion of the water contained in the coal aquifer is removed from CBM wells as produced water. The primary effects on groundwater resources would be associated with the removal of groundwater stored within coal seams and the subsequent recharge of aquifers through infiltration or injection of produced water. The combined effects of coal mining activities and other existing or reasonably foreseeable conditions on groundwater resources also are described within this chapter.

The effects of CBM development on groundwater resources would be seen as a drop in the water level (drawdown) within nearby water wells completed in the developed coal aquifers and underlying or overlying sand aquifers. Drawdown is observed when a loss in hydraulic pressure head occurs in the developed coal aquifers or in the overlying and underlying sand aquifers. The hydraulic pressure head is the vertical distance between the water level in a water well and the top of the confined aquifer in which the well is completed.

Partial removal of groundwater from a coal seam (through coal mining operations or CBM development) would reduce the hydraulic pressure head and create a hydraulic gradient toward the well or excavation. As groundwater flows into a pumping well or excavation, there would be a progressive decline in hydraulic pressure head with time and distance. The effects would be seen as progressive declines in the water level (drawdown) within nearby water wells completed in and near the developed coal aquifers.

Infiltration of produced water would initiate recovery in nearby water wells. However, continued leakage of infiltrated produced water from overlying and underlying sands into the coals would delay noticeable recovery of the sands until water removal ends. After water removal ends, water levels in nearby water wells would be expected to recover. The rate of recovery initially would be rapid due to re-equilibration of pressure heads within the coal and leakage from overlying and underlying units. The rate of recovery in the coal and sand aquifers would decrease progressively during the recovery period, as the enhanced infiltration of produced water declines.

Other potential effects on existing water wells would include changes in water yield, quality, or methane emissions. Other effects on groundwater resources would consist of potential changes in the nature of groundwater discharge to the surface or recharge to the aquifers. The nature of groundwater discharge to the surface as springs, seeps, or base flows of surface drainages could change. Surface discharge of extracted groundwater from CBM operations into surface drainages, flow-through stock reservoirs, upland or bottomland infiltration impoundments, or upland containment impoundments would enhance recharge of shallow aquifers below creek and impoundment areas. Injection of CBM produced water would recharge the aquifer units in which the injection wells are completed.

Hydrogeologic Groups

A detailed description of the geology and hydrology of the area is given in Chapter 3. This analysis focuses on the coal seams of the upper part of the Fort Union Formation, the sands of the overlying Wasatch Formation, and the alluvium underlying surface drainages.

The Wasatch Formation is exposed at the surface over most of the Project Area and overlies the Fort Union Formation. The Wasatch Formation consists of fine-grained sandstones, siltstones, claystones and coals. The sandstones tend to be discontinuous but locally are utilized for water supply. Coal zones generally are not economic for mining, or CBM development except in the area of Lake De Smet near the western margin of the PRB. Siltstones and claystones typically have low permeability and form hydraulic confining units (or aquitards) within the Wasatch sequence.

The Fort Union Formation consists of coals, sandstones, siltstones, and claystones. The coals of the upper Fort Union Formation show great variation in thickness and continuity over the PRB. Coal seams split and merge over distances of a few miles so that it is more appropriate to consider the coals as part of a hydrogeologic group rather than as individual aquifers. For the purpose of this analysis, the upper sequence of the Fort Union Formation has been subdivided into four hydrogeologic groups defined on the basis of the stratigraphic correlation of coal seams (Goolsby and Finley 2000).

All four coal groups are identifiable in the northern part of the PRB. Groups 1, 2, and 3 merge to form a thick coal unit, known as the Big George, in the central portion of the PRB. Only Group 4 is present in the southeastern part of the PRB, where it is locally known as the Wyodak coal. The outcrop areas of the coal

seams are characterized by the presence of highly permeable clinker that forms an important recharge area for the coal.

Groundwater Assumptions

Recharge to groundwater aquifers occurs from direct infiltration of precipitation (rain and snowmelt), runoff in creek valleys and standing water in playas. Infiltration is significant in areas of more permeable surface geologic units such as sandstone, or the clinker occurring in outcrop areas of the Fort Union and Wasatch Formations. Direct infiltration of precipitation provides a minimal source of recharge over most of the area because the climate and surface features prohibit significant infiltration. However, infiltration of surface water in creek valleys is considered an important source of recharge to the underlying alluvium and the shallow bedrock aquifers.

A USGS study of two ephemeral drainages in the southern part of the PRB indicated stream losses of between 0.43 to 1.44 acre-feet per mile from individual storm runoff events (Lenfest 1987) and these values were acknowledged to be underestimated. Recharge to shallow aquifers from stream valleys ranged from 3.56 to 26.5 acre-feet per mile for individual storm runoff events in the same study. Recent studies of surface water losses occurring in several drainages of the PRB receiving CBM produced water during dry weather conditions indicate that conveyance losses range from 64 percent to 100 percent of inflows (Meyer 2000, AHA and Greystone 2001, Babb 1998).

Conveyance losses include both evapotranspiration and leakage into alluvium and bedrock underlying the streams. Evapotranspiration varies seasonally, but probably accounts for less than 20 percent of the conveyance losses over the course of a year. A monthly water balance calculation for the Wild Horse Creek drainage found that evapotranspiration accounted for approximately 18 percent of the conveyance loss associated with the surface discharge of CBM produced water within the drainage basin (Hydrologic Consultants Inc. 2001). Recharge of shallow aquifers due to leakage from rivers or streams is likely to account for over 80 percent of the conveyance loss.

For the purpose of this analysis, discharge of CBM produced water to surface drainages is assumed to result in an 80 percent conveyance loss, 82 percent of which is due to infiltration and 18 percent due to evapotranspiration. These values are averaged from various studies of surface water losses in creek flows in several drainages of the PRB (Meyer 2000, AHA and Greystone 2001, Babb 1998, Lenfest 1987) and result in an estimated net recharge to shallow groundwater of almost 66 percent of the water produced.

For the purpose of this analysis, where produced water would be discharged to infiltration impoundments designed to allow infiltration, water would infiltrate at an estimated rate of eight feet per year. This estimated infiltration rate is used in the groundwater impact analysis to ensure that the environmental effects that could result from substantial infiltration of produced water are considered in the groundwater model analysis. There would be no evapotranspiration of this infiltration water so that the net recharge to shallow groundwater would be 100 percent of the produced water that infiltrates the surface.

For the purpose of this analysis, where produced water would be discharged to large containment impoundments constructed in a manner that allows minimal infiltration, an estimated 10 percent of the water stored in these reservoirs would infiltrate the surface. There would be no evapotranspiration of this infiltration water so that net recharge to shallow groundwater would be 10 percent of the produced water discharged into containment impoundments.

For the purpose of this analysis, all of the produced water used for land application would be used consumptively. There would be no net recharge from this water handling option.

Injection of CBM produced water results in recharge to the zone of injection. For purpose of this analysis, injection is assumed to be deep injection (such as into the sands of the lower Fort Union Formation). There would be no net recharge to the Wasatch sands or the coal zones within the Fort Union Formation from this water handling option.

Groundwater assumptions and the fate of the CBM-produced water are summarized by alternative in Table 4–1, Table 4–2, and Table 4–3.

Hydraulic connection between the sands of the Wasatch Formation and the coals of the upper Fort Union Formation is limited due to the low permeability claystones that separate the two units. However, if the hydraulic head (water level) in the coal is naturally lower than in the overlying sands, then there is potential for leakage from the sands into the coal. Based on observation of water levels in nested monitoring wells, significant leakage into developed coals is only expected where Wasatch sands occur within approximately 100 feet above or below the coal zone. The natural leakage rate typically would be extremely small, but taken over a large area can amount to a significant portion of the total recharge into the coal.

As sands in the Wasatch Formation tend to be discontinuous, the amount of leakage would also be limited by the areal extent of sands that exist within 100 feet of the coal. Locally, the hydraulic connection between the coal and Wasatch sands may be enhanced if the integrity of the confining layer is compromised by water supply wells screened through both the coal and the overlying sands, deteriorating well casings, or poorly plugged oil and gas wells or exploratory drill holes. Leakage from the Wasatch sands into the coal also may be enhanced if water levels in the coal are lowered as a result of coal dewatering activities. Due to the limited hydraulic communication between the coal and the overlying Wasatch sands, a significant period of time (typically several years) would likely pass before noticeable drawdown (drop in water level) in the sands would be apparent.

Table 4–1 Groundwater Assumptions and the Fate of the CBM-Produced Water for Alternatives 1 and 3

	Surface Discharge				Infiltration			Containment		LAD	Injection
Sub-watershed	Runoff (Percent)	Infiltration (Percent)	Evapotranspiration (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Consumptive Use	Deep Recharge
Upper Tongue River	7	23	5	0	30	15	3.8	1.0	5.2	0	10
Upper Powder River	15	49	11	0	10	5	1.9	0.5	2.6	0	5
Salt Creek	11	36	8	0	23	12	1.9	0.5	2.6	0	5
Crazy Woman Creek	14	46	10	0	3	2	1.9	0.5	2.6	15	5
Clear Creek	7	23	5	0	27	13	1.9	0.5	2.6	10	10
Middle Powder River	13	43	9	0	7	3	3.8	1.0	5.2	10	5
Little Powder River	13	43	9	0	7	3	3.8	1.0	5.2	10	5
Antelope Creek	11	36	8	0	23	12	1.9	0.5	2.6	0	5
Upper Cheyenne River	11	36	8	0	23	12	1.9	0.5	2.6	0	5
Upper Belle Fouche River	9	30	6	0	27	13	1.9	0.5	2.6	0	10

Table 4–2 Groundwater Assumptions and the Fate of the CBM-Produced Water for Alternative 2A

	Surface Discharge				Infiltration			Containment		LAD	Injection
Sub-watershed	Runoff (Percent)	Infiltration (Percent)	Evapotranspiration (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Consumptive Use	Deep Recharge
Upper Tongue River	2	7	1	0	40	20	3.8	1.0	5.2	10	10
Upper Powder River	5	16	4	0	37	18	1.9	0.5	2.6	10	5
Salt Creek	0	0	0	0	40	20	3.8	1.0	5.2	5	25
Crazy Woman Creek	2	7	1	0	40	20	3.8	1.0	5.2	10	10
Clear Creek	2	7	1	0	40	20	3.8	1.0	5.2	10	10
Middle Powder River	5	16	4	0	34	17	3.8	1.0	5.2	10	5
Little Powder River	5	16	4	0	34	17	3.8	1.0	5.2	10	5
Antelope Creek	8	26	6	0	27	13	1.9	0.5	2.6	10	5
Upper Cheyenne River	8	26	6	0	27	13	1.9	0.5	2.6	10	5
Upper Belle Fouche River	9	30	6	0	20	10	1.9	0.5	2.6	10	10

Table 4–3 Groundwater Assumptions and the Fate of the CBM-Produced Water for Alternative 2B

	Surface Discharge				Infiltration			Containment		LAD	Injection
Sub-watershed	Runoff (Percent)	Infiltration (Percent)	Evapotranspiration (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Consumptive Use	Deep Recharge
Upper Tongue River	7	23	5	0	23	12	3.8	1.0	5.2	10	10
Upper Powder River	8	26	6	0	27	13	1.9	0.5	2.6	10	5
Salt Creek	0	0	0	0	40	20	3.8	1.0	5.2	5	25
Crazy Woman Creek	6	20	4	0	30	15	1.9	0.5	2.6	10	10
Clear Creek	6	20	4	0	30	15	1.9	0.5	2.6	10	10
Middle Powder River	9	30	6	0	20	10	3.8	1.0	5.2	10	5
Little Powder River	9	30	6	0	23	12	1.9	0.5	2.6	10	5
Antelope Creek	10	33	7	0	20	10	1.9	0.5	2.6	10	5
Upper Cheyenne River	10	33	7	0	20	10	1.9	0.5	2.6	10	5
Upper Belle Fouche River	10	33	7	0	17	8	1.9	0.5	2.6	10	10

Partial isolation of the sand aquifers overlying the coal is indicated in the results of the BLM groundwater monitoring of the Marquiss CBM project, which has had the longest history of operation (since 1993). The BLM has monitored two paired wells since the beginning of the project. MP-22C is completed in the coal and MP-22S completed in the first overlying sand zone, approximately 40 feet above the coal. Water level decline of over 250 feet has been observed in the coal monitoring well, while a water level decline of approximately 20 feet has been observed in the overlying sand aquifer, after more than eight years of monitoring. For the purpose of this analysis, the partial isolation of the sand aquifers overlying the coal that has been documented by BLM monitoring is assumed to apply to this analysis.

Through time, many clinker deposits have become saturated as a result of the infiltration of precipitation and snowmelt. "Ponding" of water may occur along the interface where clinker meets less permeable coal and sediments of the Wasatch Formation. Springs may form at the base of the clinker deposits. Moyer Springs, located north of Gillette, is a good example of this type of occurrence.

Regional groundwater flow in the eastern part of the PRB is generally to the northwest (downdip) towards potential discharge areas in the north central part of the PRB (Daddow 1986). Coal wells in the vicinity of the Powder River exhibit flowing artesian conditions indicative of upward flow gradients. This supports the potential for groundwater discharge along the northern part of the Powder River, although physical evidence for this, in the form of springs and sustained river base flow, are not readily apparent. It is assumed that most of the discharge is diffuse and may be consumed by evapotranspiration so that it does not appear as surface flow. A significant portion of deeper groundwater flow in the PRB probably discharges farther north, into the Yellowstone River drainage basin.

Groundwater Modeling Methodology

Numerical groundwater flow modeling was used to predict the impacts of the Project. Modeling was necessary because of the large extent, variability, and cumulative stresses imposed by mining and CBM development on the Fort Union and Wasatch aquifer units. Assessment of CBM development impacts has been performed for earlier environmental assessments for the Marquiss, Lighthouse, North Gillette, and South Gillette areas (BLM 1992a, 1995a, 1995b, 1996, and 1997a). A detailed modeling study was completed for the Little Thunder drainage basin in the southeastern part of the PRB (Wyoming Water Resources Center 1997). Modeling of the eastern part of the PRB was performed for the Wyodak EIS (BLM 1999e). The information from earlier studies was reviewed and has been incorporated wherever practical into the modeling work for this analysis.

The computer model used to complete the groundwater analysis for this Project is briefly described here. The complete technical description of this groundwater analysis is found in the *Technical Report for the Powder River Basin Oil and Gas Project, Groundwater Modeling of Impacts Associated with Mining and Coalbed Methane Development in the Powder River Basin (*AHA and Greystone 2001), on file at the BLM Casper Field Office in Casper, Wyoming and at the BLM Buffalo Field Office in Buffalo, Wyoming. This report describes the specific hydro-

geologic data on which the model was based. It also describes the numerical model and model assumptions in more detail.

The hydrogeologic model code selected was the USGS Three Dimensional Finite Difference Modular Groundwater Flow Model MODFLOW-98. This model code is widely accepted by regulatory agencies and currently is used by the BLM.

The regional model consists of 17 layers. The lowermost three layers (layers 15, 16, and 17) represent the lower members of the Fort Union Formation and the claystone aquitard separating these members from the overlying coals in the upper portion of the Fort Union Formation. The coal-bearing units of the upper portion of the Fort Union Formation are represented by layers 8, 10, 12, and 14 in the model. The intervals between the coal-bearing units are represented by layers 9, 11, and 13. As the coal-bearing units split and merge in the PRB, the hydraulic properties assigned to the layers representing both coal-bearing units and intervening units would change accordingly. The coal-bearing units transition into more highly permeable clinker in outcrop areas. Overlying the four coal-bearing units is a layer (layer 7) representing claystones within the Wasatch Formation that act as a confining unit between the coal-bearing units and the discontinuous sandstones within the Wasatch Formation. Layers 1 through 6 represent the Wasatch Formation, consisting of alternating layers of discontinuous sandstone units and claystone/siltstone units. The discontinuous nature of the sandstones in the Wasatch Formation was modeled by assigning hydrologic parameters to these layers that are representative of mixed sandstone and claystone/siltstone units. The uppermost layer (layer 1) represents surface geologic units, including claystones, sandstones, and alluvial sediments within creek valleys.

Other geologic boundaries that were incorporated into the model include faults and lineaments where these are suspected of having a significant influence on groundwater flow regimes. Faults may act as impermeable (no-flow) boundaries or zones of flow restriction, and lineaments as zones of augmented hydraulic conductivity in the model.

For geographic locations where mining would occur, the mining sequence was simulated as incremental impacts in one-year stress periods from approximately 1975 (the earliest mining along the Wyodak outcrop, with the exception of the Wyodak mine located east of Gillette) to the present. Predictive simulations of impacts were modeled to 2225, approximately 200 years beyond the end of reasonably foreseeable mine plans, in 2021. Historic mining records and life-of-mine plan maps on file with the Wyoming Department of Environmental Quality in Cheyenne were used to develop historic mine sequences and to project the approximate future mining sequence. Although life-of-mine plans are dynamic and may change in future years, they give a general projection of likely coal removal sequences and mine progression. Annual progress of the mine plans was superimposed on the grid as drains within the model, with the pits left open for three years and then closed. Mining drains are set with drain elevations positioned just above the base of the mined coal seam. When mined areas are reclaimed, the drains are removed from the model so that water levels can recover.

Current CBM production was simulated in the area using the historic operational data from the existing fields. Future CBM development was simulated using the

estimate of future development described in Chapter 2. Annual progress of CBM development was simulated as drains within the appropriate model cells. These drains were set at an elevation of approximately 50 feet above the top of the developed coal seam. Historic CBM production sequences were simulated using water production data available from the WOGCC. Future CBM water production estimates assumed an average operational life of seven years for each projected CBM well.

Model calibration was done to pre-mining water levels, or in a few cases, earliest available static water levels. This was assumed to represent steady state conditions. The model was calibrated in transient state by matching against available historic water level monitoring data and CBM well production data. Sources of the water level monitoring data used to calibrate the model include Daddow (1986), the Gillette Area Groundwater Monitoring Organization (GAGMO), individual mine data, and the BLM.

The groundwater flow model was used to predict the areal extent of aquifer drawdowns due to the superimposed stresses of the proposed CBM development and mining operations on a year-by-year basis. CBM development of the PRB began in 1989. The Rawhide Butte field represented the first commercial CBM production in the PRB. Considerable CBM development has occurred in the Marquiss and Lighthouse areas south of Gillette, and in the vicinity of the Buckskin and Eagle Butte mines north of Gillette. Information from the WOGCC database indicates that as of May 2001 there were 5,854 producing CBM wells and an additional 2,520 shut-in wells in the PRB. The approximate locations and timing of CBM development through 2001 were input into the model based on actual well records. The location and timing for future CBM development were based on permit applications and projections contained in Chapter 2.

The following information used in the model analysis is described in Chapter 2. New CBM wells are projected by year and sub-watershed. The proportion of CBM produced water that would be handled using discharge to surface drainages, infiltration, containment, land application, and injection also is projected for each sub-watershed.

The model used water production data from the WOGCC as the source for input of drains. It is assumed that future wells would be drilled over a ten-year period from March 2002 through March 2012 and each would have a seven-year life span as described in Chapter 2. A total of 39,367 new wells were input into the model as drain nodes with appropriate time schedules. The producing intervals of the wells were distributed among the four coal-bearing units (layers of the model) based on existing production or the thickness and depths of the coals in any given area. In many areas, more than one coal interval would be produced, and this is reflected in the model where more than one well per well pad is projected.

The effects of the various water handling methods were simulated in the model by applying additional recharge to the portion of each sub-watershed affected by CBM development, on a year-by-year basis during the production period. The recharge amount was based on modeled water production, the projected proportion of water handled by the various methods, and the projected infiltration associated with each water handling method. The additional recharge was converted

to a year-by-year infiltration rate based on the area of CBM development in each sub-watershed.

Alternative 1

The following discussion outlines the projected effects on water yield, and aquifer characteristics or conditions, including groundwater quantity, quality, and use.

Water Yield (CBM Produced Water)

Table 2–8 shows the modeled quantity of water that would be removed during CBM development occurring from 2002 through 2017. The projected discharge is summarized by sub-watershed. This CBM produced water would be derived primarily from storage within the developed coals and from groundwater contained in sand units leaking into the coals as a result of coal depressurization. Water removal would be projected to peak during 2007, at a rate of 462,400 acre-feet per year. Depending on the water handling practices used within each sub-watershed, an estimated 55 to 68 percent of the pumped water would be recharged to the groundwater system as a result of infiltration along creeks and below impoundments, or direct injection.

Aquifer Characteristics

The removal of water from the coal seam is unlikely to have any measurable effects on the physical characteristics of the aquifer, and its ability to store or transport water. Subsidence is discussed under Geologic Hazards starting on page 4–84.

Aquifer Conditions

The removal of water from the coal seam and the subsequent disposal of the produced water likely would have the following effects on conditions existing within affected aquifers at various times during or after CBM development.

Alluvial Aquifers

Depending on the water handling practices used within each sub-watershed, an estimated 80 to 95 percent of the groundwater produced from CBM operations would be released to surface drainages or impoundments. A portion of the released water would recharge the alluvium. Several studies of water flow losses in creeks during dry weather periods have shown that a considerable portion of the discharged water infiltrates the alluvium within a few miles of the surface discharge outfall.

Alluvium with near-surface water tables would likely see increases in water levels from CBM produced water discharges. The increase in water level may be exhibited as standing water in areas not previously displaying this condition or as wetland development.

The City of Gillette currently pumps the alluvium of Donkey Creek within the community to maintain lower water levels. The city's pumping rate would likely

have to increase to maintain current water levels during continued CBM field development.

Fort Union Coal Aquifer

Drawdown

Under Alternative 1, the model-projected composite maximum drawdown from CBM development occurring in the coal-bearing units within the upper portion of the Fort Union Formation would occur during the period 2006 to 2009 depending on location. The modeled composite drawdown for the year 2009 is shown in Figure 4–1 and the modeled composite drawdown for the year 2012, after the last Project wells are drilled, is shown in Figure 4–2. Because coal mining and CBM operations are dynamic, the maximum areal extent of drawdown may change over time and may increase in some areas of the PRB while recovering in others. The maximum drawdowns in any given watershed generally coincide or closely follow the period of peak water production in the watershed (Table 2-8). The CBM water production in the Project Area under Alternative 1 is expected to peak in 2007 (Table 2-8).

The maximum extent of projected drawdown in the target coals, defined as a drawdown of at least ten feet, extends 10 to 12 miles beyond areas of CBM development. Projections of maximum drawdown and extent of drawdown are based on the projected locations of CBM development. Actual drilling locations and density of drilling may result in shifts of drawdown contours from the projections illustrated in Figure 4–1 and Figure 4–2.

Maximum projected drawdowns would occur in the centers of CBM development. Within the northern portion of the Project Area, CBM production would occur from two or more coal-bearing units. Drawdown would depend on the depth of the target coal(s) below the surface. In deep areas of the basin, such as the northwestern portion of the basin, model-projected composite maximum drawdowns would exceed 1,200 feet. In shallow areas of the basin, such as the southeastern portion of the basin, modeled drawdowns would be 200 to 400 feet over most of the active CBM well fields.

The projected rate of coal aquifer drawdown is presented by a graph of modeled drawdown versus time at selected locations in the model. The locations of calibration monitoring wells are shown on Figure 4–3. A water level drawdown graph for selected monitoring wells in the Project Area is shown in Figure 4–4. The graphs show that the water level changes in the coal aquifer that would be induced by CBM development tend to be fairly rapid.

Initial hydraulic head in the coal, as measured by the water level in a well completed in the coal, may be several hundred feet above the top of the coal. This is particularly true in the deep portions of the PRB where the depth to the coal may be over 1,300 feet. Removal of water from the coal in these areas during CBM development could result in drawdown of the hydraulic head to the top of the coal at the location of the pumping wells. For reference, where the depth to the coal is 1,200 feet and the depth to water in a well tapping the coal is 400 feet, an initial hydraulic head of 800 feet would exist. Even though the thickness of the coal itself may only be 100 feet, maximum drawdown in this example could be as much as 800 feet.

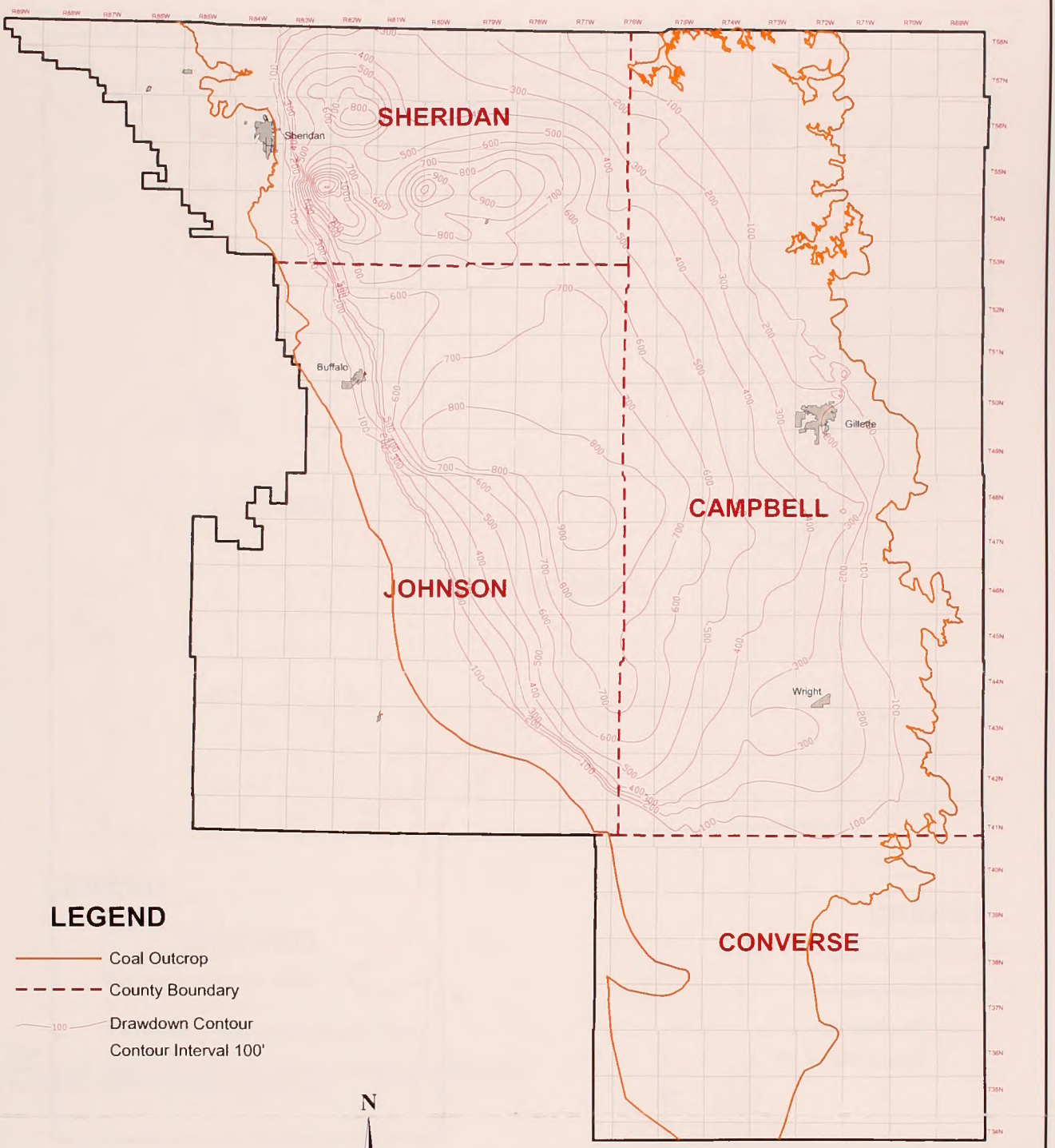
Recovery

Recovery of water levels in the coal would become apparent after water production started to decline. Water production is expected to start declining about 2008 and end about 2018. Recharge to the coal comes primarily from the redistribution of stored water in the surrounding coal and continued slow leakage from overlying Wasatch sand aquifers and underlying Fort Union Formation sand aquifers. By 2030, water levels in the coal are projected to recover to within 55 to 65 feet (75 to 80 percent) of pre-operation levels. The maximum extent of the 10-foot drawdown is projected to extend 10 to 12 miles from the limit of CBM development (Figure 4–5).

Initially, recovery would be primarily due to redistribution of groundwater stored in the aquifer. When the stresses of pumping are removed, the groundwater in storage outside the CBM development areas would resaturate and repressurize the areas that were partially depressurized during operations. The amount of groundwater storage within the coal and within the sand units above and below the coal is enormous, and redistribution would be projected to result in a fairly rapid initial recovery of water levels in the coal. The model projects that this initial recovery period would occur over 14 to 16 years, with water levels recovering to within 55 to 65 feet (75 to 80 percent) of pre-operational conditions within this period.

Complete water level recovery would be a very long-term process because actual recharge to the coal aquifer would need to replace groundwater removed from storage during CBM operations. Most of this recharge would come from leakage from overlying and underlying sand and undeveloped coal units. These units would be, in turn, recharged from surface infiltration. Recharge rates would increase temporarily as a result of infiltration of CBM water discharged to impoundments and streams. However, based on modeling and information from nested wells, it would take tens of years before these surface recharge influences would appear in the coal. Recharge to the coal in the central part of the PRB through surface infiltration at the outcrop areas would take even longer. Coal mining along the eastern and northwestern subcrop would result in minimal recharge to the coal while the mines are active, due to the groundwater sink caused by pit dewatering. As mines are reclaimed and eventually shut down, the backfilled areas would become long-term recharge zones for the coal aquifer. Infiltration through backfill areas may be very significant because the permeability of the backfill materials tends to be much higher than in the original unmined materials. In addition, most of the creeks would be diverted over these backfilled areas, providing an important source of recharge water.

The projected recovery of water levels following the cessation of CBM development and coal mining operations is illustrated in Figure 4–5 for selected locations in the model. The graphs show water levels recovering to within 55 to 60 feet (75 to 80 percent) of pre-operational conditions within 14 to 16 years following cessation of CBM operations. However, the rate of recovery would slow dramatically after this initial recovery period, eventually recovering to within less than 20 feet (95 percent) of pre-operational conditions over the next hundred years or so.

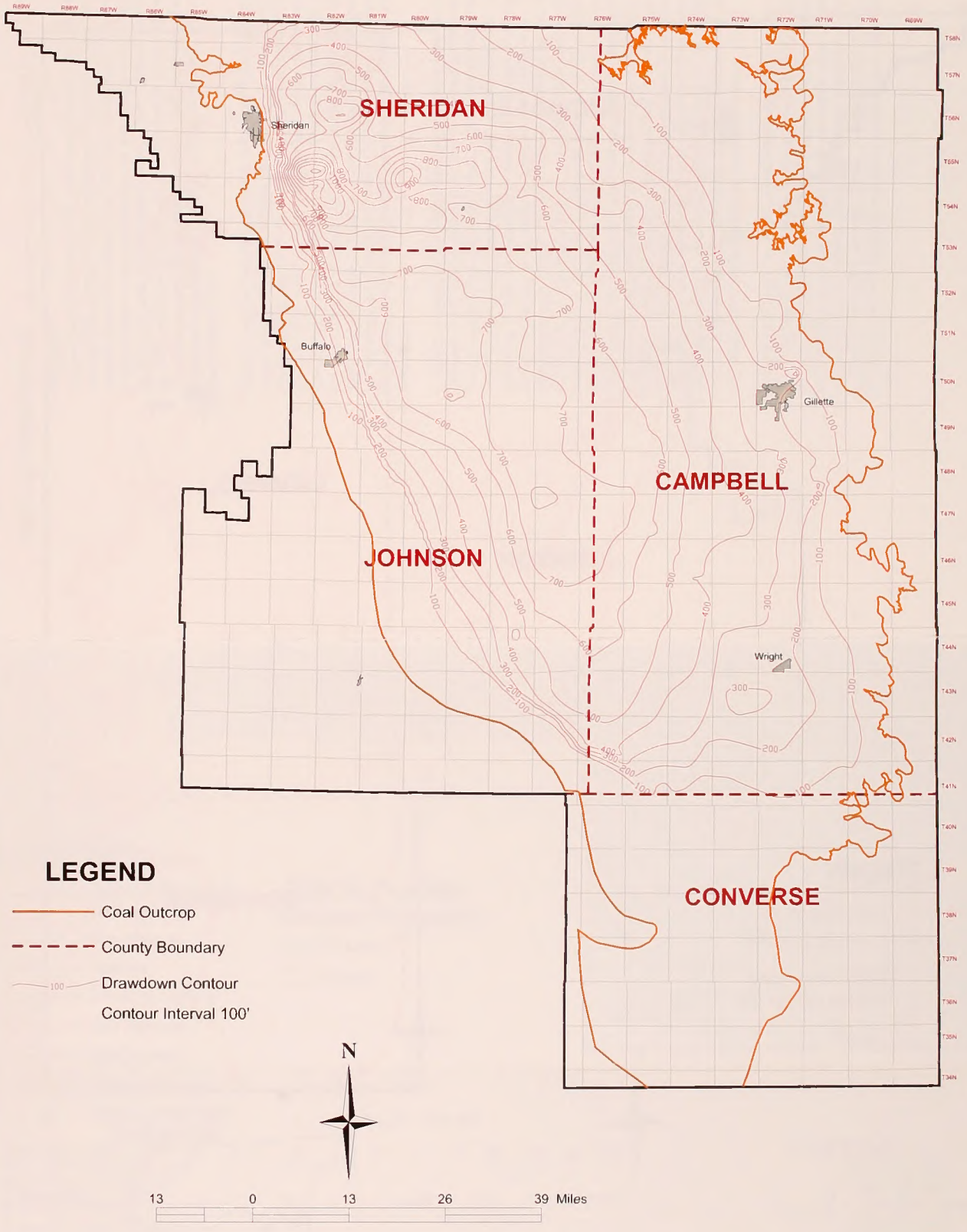


POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 4-1
MODELED COMPOSITE DRAWDOWN IN UPPER FORT UNION COALS- YEAR 2009

MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP2.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.

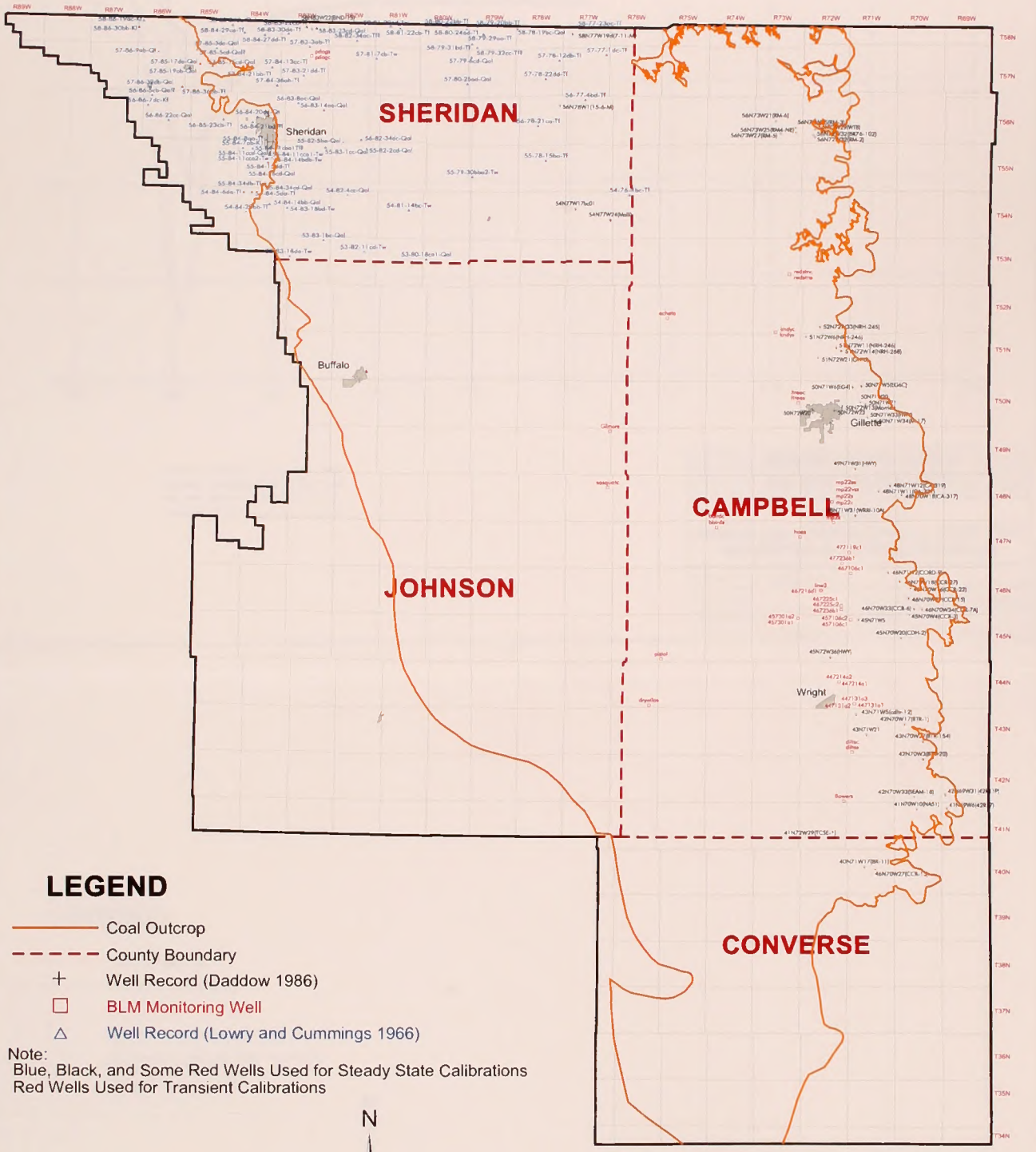


POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 4-2
MODELED COMPOSITE DRAWDOWN IN UPPER FORT UNION COALS-YEAR 2012

MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.



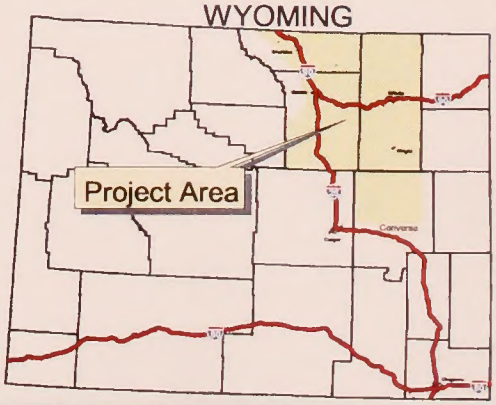
LEGEND

- Coal Outcrop
- County Boundary
- \+ Well Record (Daddow 1986)
- □ BLM Monitoring Well
- △ Well Record (Lowry and Cummings 1966)

Note:
Blue, Black, and Some Red Wells Used for Steady State Calibrations
Red Wells Used for Transient Calibrations

N

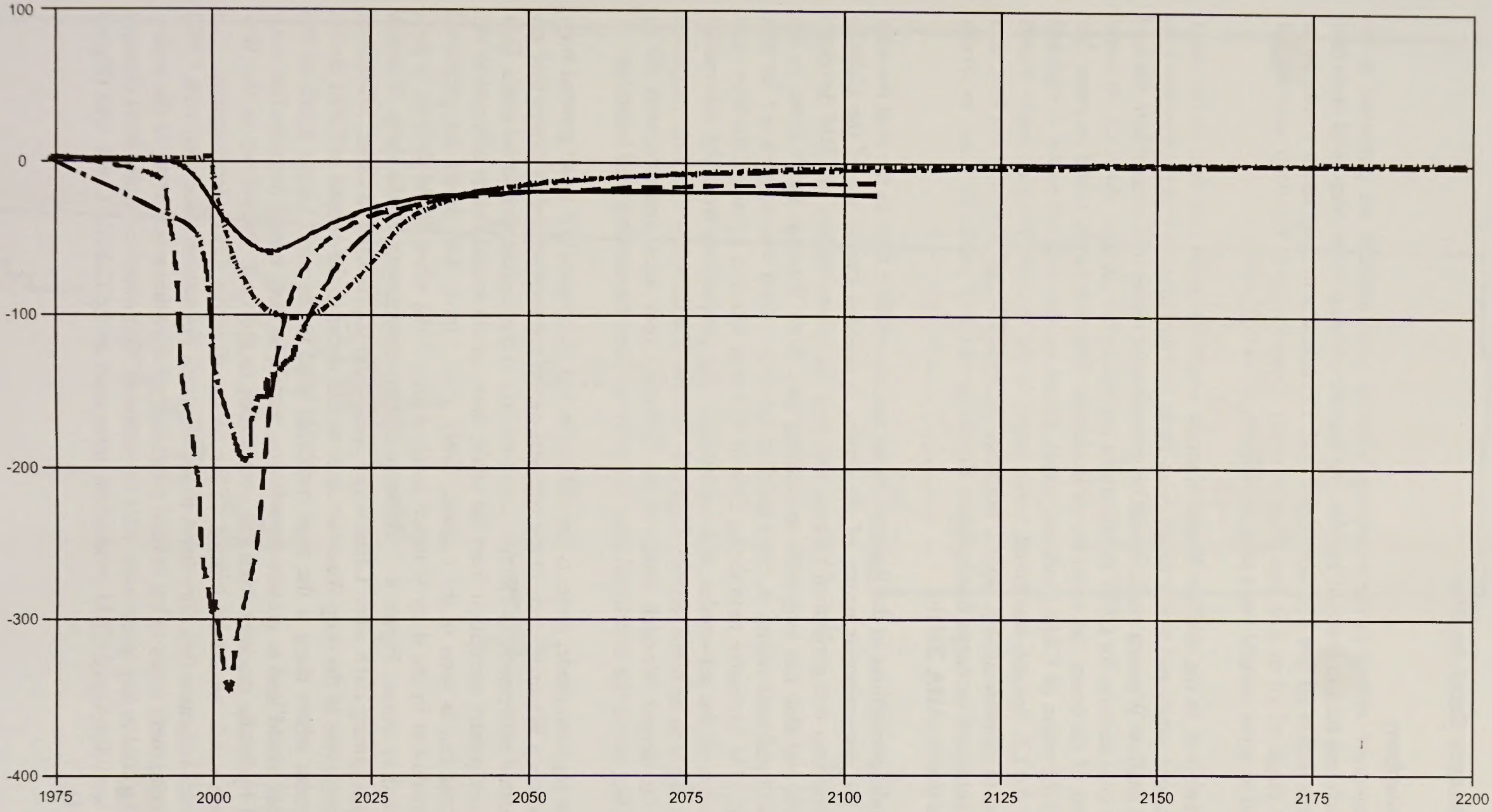
13 0 13 26 39 Miles



POWDER RIVER BASIN OIL/GAS EIS PROJECT	
FIGURE 4-3 LOCATION OF CALIBRATION MONITORING WELLS	
MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 FIGURE 4-2.dwg
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.





AHA Well - Coal - Little Powder
AHA Well - Sand - Little Powder
MP22C - Coal - Belle Fourche
MP22C - Sand - Belle Fourche

POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 4-4
MODELED DRAWDOWN vs. TIME FOR SELECTED MONITORING WELLS

MODEL RUN: From 1999-2224 (11-25-01)

Date: 12/20/01	Drawing File: 1011 FIGURE 4-4.dwg
Scale: As Noted	DRAWN BY: ETC

Wasatch Sand Aquifer

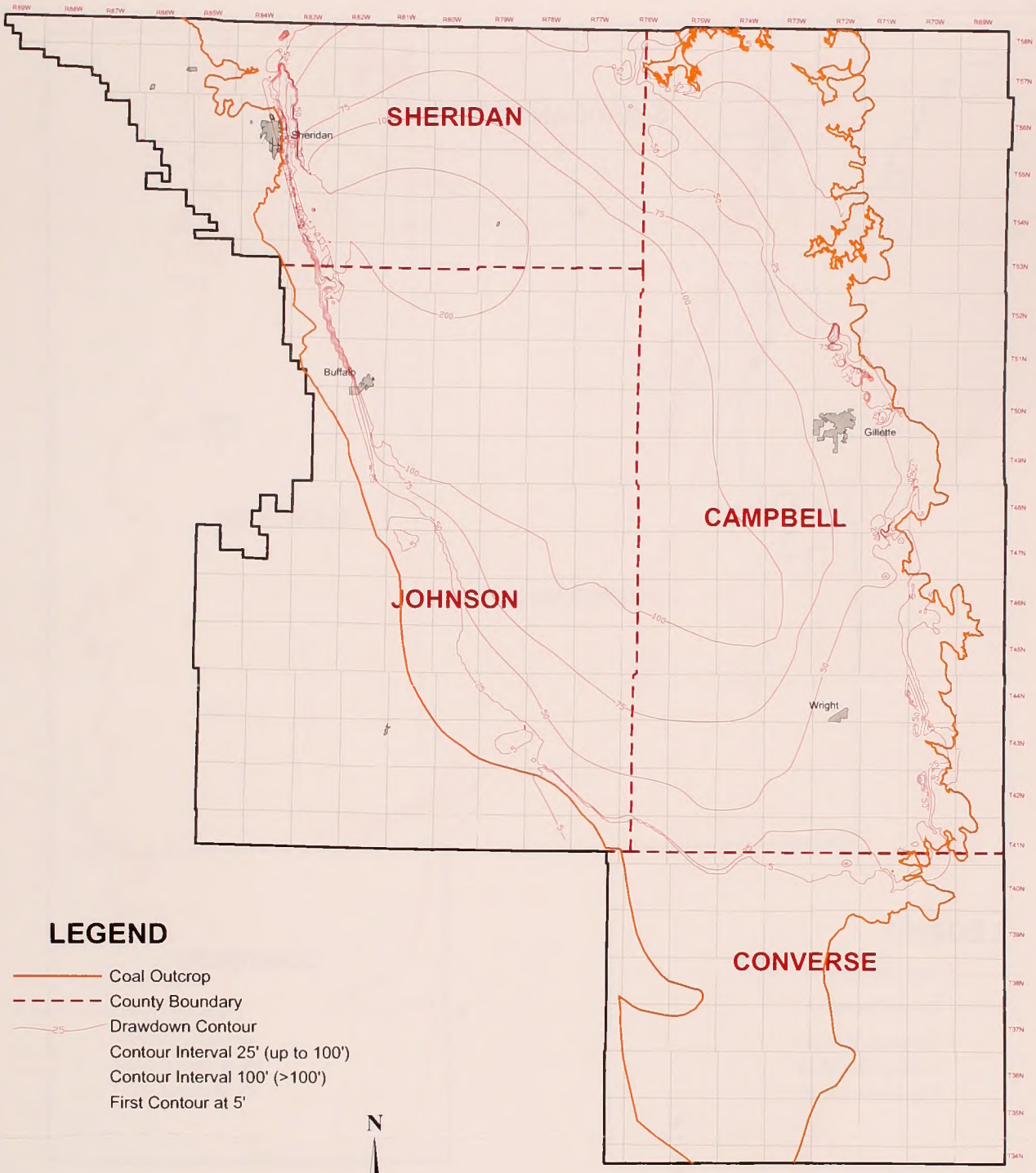
Drawdown

Drawdown effects in the overlying Wasatch sand aquifers are projected to be much less than in the coal aquifer, but may be noticeable for deep sand units that occur within 50 feet of a developed coal. Drawdowns in deep sands would be in the range of 10 to 250 feet in most areas. Drawdowns in the deep sand would tend to occur several years after drawdown in the coal occurs.

Drawdown in the shallow Wasatch sands would be much less than in the deep Wasatch sands and would range from 10 to 100 feet in most areas. Drawdown in the shallow Wasatch sands would be greatest near mines and areas where the target coal seam(s) for CBM development are nearer the surface. However, in some areas of the basin, the water levels in shallow Wasatch sands would increase due to infiltration of CBM produced water. Based on the detailed model completed for the LX Bar sub-watershed, water levels in the shallow Wasatch sands would tend to increase slowly, with a projected increase of approximately ten feet, due to enhanced recharge from surface discharge of CBM produced water to creeks and ponds (AHA 2001b).

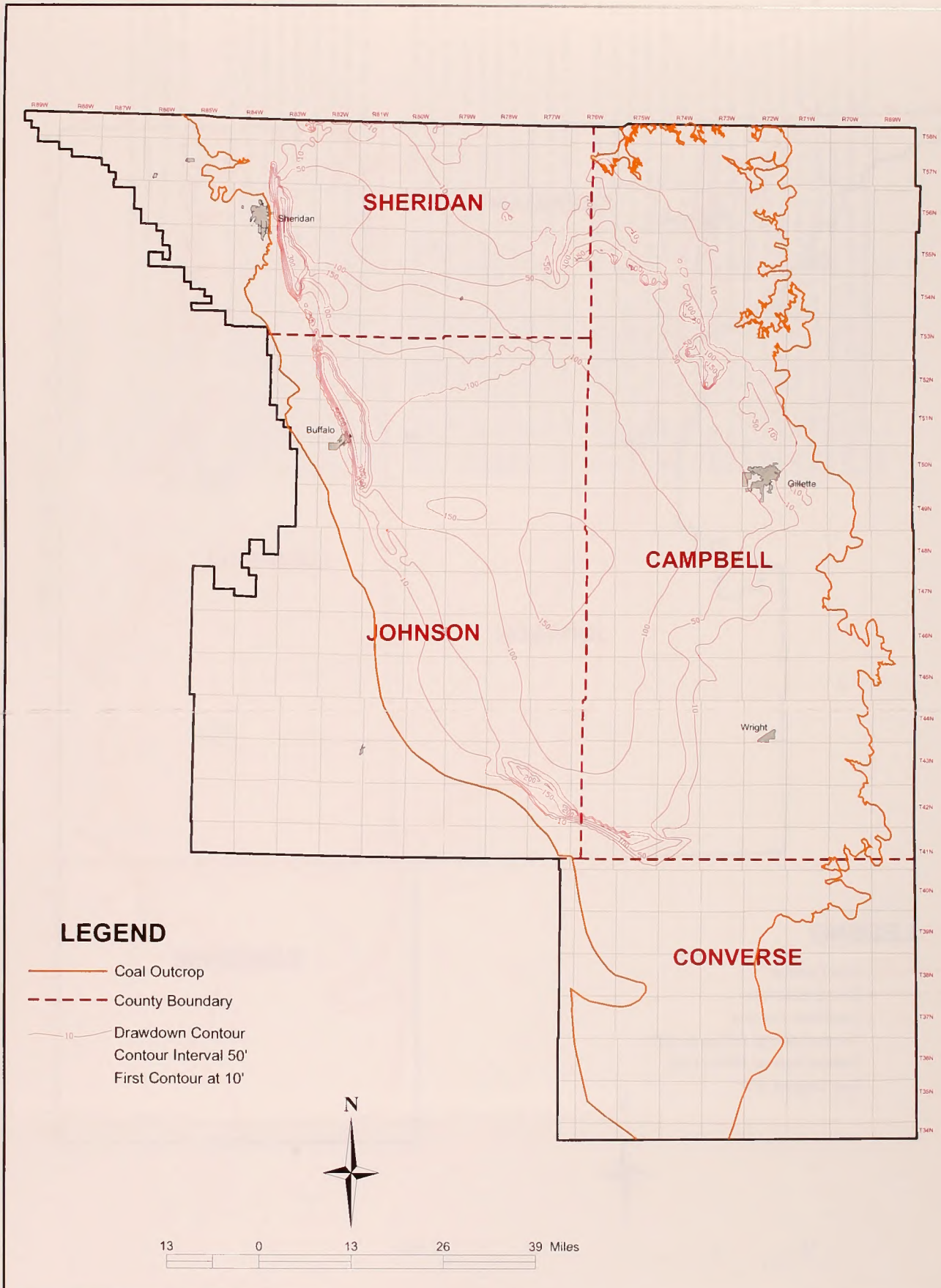
Model projections in the Wasatch sands are less reliable than in the coal because of the discontinuous nature of the sands. A detailed evaluation of the Caballo Creek area was performed because this area has a long history of CBM development and also has long-term monitoring data from Wasatch sands close to the developed coal seams. A more detailed sub-area model was constructed for this area. The extensive monitoring data in this area allowed a more definitive calibration of the sub-model, and accordingly, the projections from the sub-model are likely to be more reliable. Figure 4–4 shows the drawdown vs. time projected in the deeper Wasatch sands of the Caballo Creek area, approximately 40 to 50 feet above the developed coal, for some selected monitoring well locations.

The regional model projects the effects on Wasatch sands in a more general way. The deep Wasatch sands in the regional model are represented by layers that are situated between 50 to 150 feet above the top of the highest developed coals. Due to the greater separation from the coals, these sands would not be affected to the extent that is seen in the Caballo Creek area. Figure 4–6 shows the projected drawdowns in the deep Wasatch sands during 2012 when CBM drilling is projected to cease. Figure 4–7 shows projected drawdowns in the deep Wasatch sands during 2018 when CBM water production is projected to cease. Maximum drawdowns in the deep Wasatch sands would occur in the centers of CBM development where there is the most available head in the coal. Larger heads in the coals would lead to greater drawdowns, which, in turn, would increase the vertical hydraulic gradient from the overburden to the coal. Drawdown in the Wasatch sands would be limited to the areas of active CBM development. The model indicates that drawdown in the Wasatch Formation associated with CBM development tends to lag several years behind drawdown occurring in the underlying coal in any given area. This is consistent with observed water level changes in well-developed CBM production areas such as the Caballo Creek area (Figure 4–4).



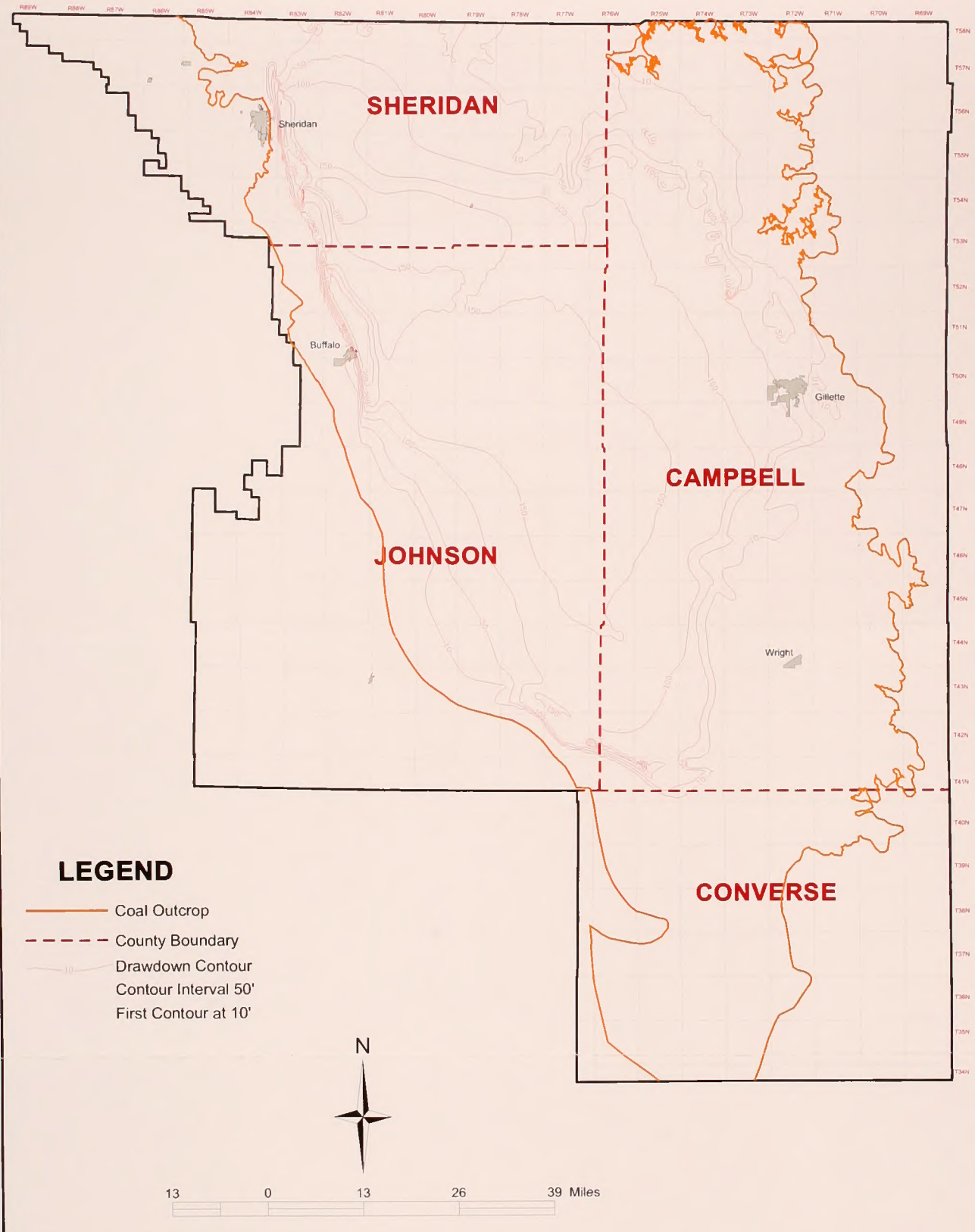
POWDER RIVER BASIN OIL/GAS EIS PROJECT	
FIGURE 4-5 MODELED WATER LEVEL RECOVERY IN UPPER FORT UNION COALS-YEAR 2030	
MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.



POWDER RIVER BASIN OIL/GAS EIS PROJECT	
FIGURE 4-6 MODELED WATER LEVEL CHANGE FOR DEEP WASATCH SAND-YEAR 2012	
MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP2.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.



POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 4-7
MODELED WATER LEVEL CHANGE FOR DEEP WASATCH SAND-YEAR 2018

MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP2.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.

The drawdown in the Wasatch sands would continue after CBM operations cease and coal water levels start to recover, because the Wasatch Formation is a source of recharge to the coal. There likely would be localized areas in the Wasatch sands that would see greater drawdowns than projected by the model, due to conducive faults, poorly grouted well bores, and exploration borings.

Recharge

Some of the groundwater released to surface drainages or impoundments would recharge shallow bedrock (Wasatch Formation). A portion of the released water would recharge the alluvium. In turn, the alluvium along many of the creek valleys would recharge the underlying Wasatch sands. Several studies of water flow losses in creeks during dry weather periods have shown that a considerable portion of the discharged water infiltrates the alluvium within a few miles of the surface discharge outfall. Bedrock monitoring wells located close to areas where CBM produced water is discharging into creeks or impoundments have shown water level increases, indicating that this recharge is occurring. The nature of recharge in any area is directly related to the permeability of the surface exposures of the Wasatch Formation occurring under creeks and ponds.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations was obtained from the model output for each of the affected sub-watersheds (Table 2-8). This projected water production would be managed according to the water handling options identified for each sub-watershed under Alternative 1 (Table 2-9). The projected net recharge is calculated based on the percentage of the produced water handled by each method and the projected loss due to infiltration.

The calculated net recharge volume, on a year-by-year basis, was divided by the projected CBM development area within each sub-watershed to obtain an equivalent recharge rate for the area, in inches per year. This additional recharge was then input into the model for the area of CBM development within each watershed during the time period when CBM operations are expected to be active.

The projected water level change in shallow Wasatch sands during 2005 and 2012 is shown in Figure 4–8 and Table 4–9. Water levels in the shallow sands are projected to rise initially in some areas during CBM development due to the modeled recharge of CBM produced water, before being drawn down.

Recovery

Recovery in the deep Wasatch sands would tend to occur once coal water levels recovered substantially and induced leakage from the deep Wasatch sands into the coal became minimal. The model projects that water levels in the areas of highest drawdown would recover within 30 to 35 feet (50 to 70 percent) of pre-operational conditions within 15 to 17 years following cessation of CBM operations. Water levels would eventually recover to within less than 20 feet (80 percent) of pre-operational conditions over the next hundred years or so (Figure 4–10).

The projected recovery of water levels in the deep Wasatch sands following the cessation of CBM development would be slow until coal water levels recover, because the sands would continue to recharge the coal even after CBM development ceases. Complete recovery to pre-operational conditions may take many years.

Projected recovery of water levels in the shallow Wasatch sands is shown in Figure 4–11 for the year 2030. Complete recovery to pre-operational conditions may take many years.

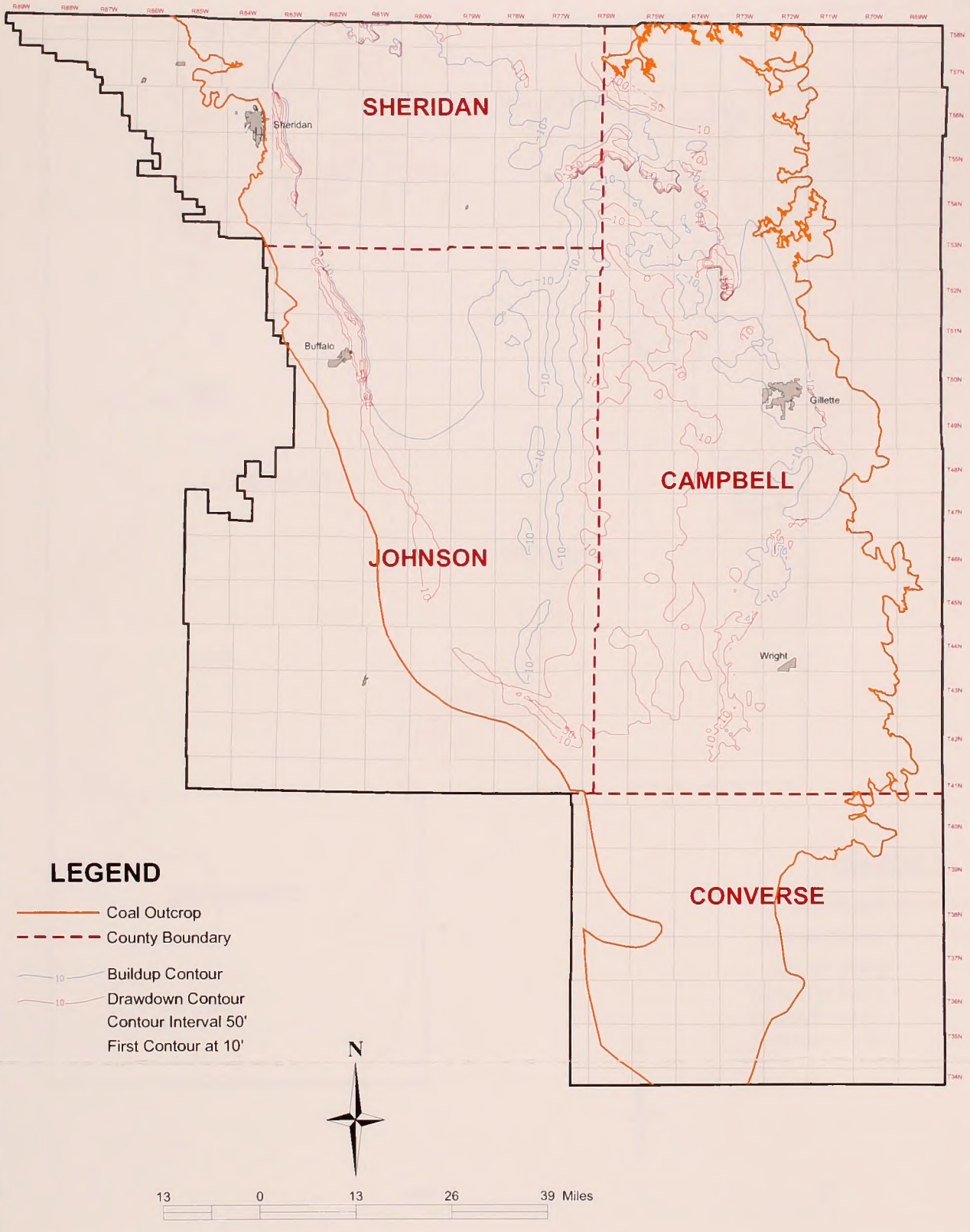
Groundwater Use

Water Wells

Impacts to individual water wells completed within the coal, and in sands above the coal, would depend on proximity to CBM production wells, depth and completion interval of the water well, and the water well yield required to maintain it as a usable source. Drawdown of water levels in coal aquifers caused by CBM development potentially may impact individual well users by reducing well yield. Refer also to 'Methane Emissions' discussion presented below.

Under Alternative 1, the model projects over 1,200 feet of coal aquifer drawdown near the centers of active CBM development, with drawdown in excess of 10 feet extending some 10 to 12 miles from these areas (Figure 4–1). The maximum available drawdown (the hydraulic pressure head) in the coal aquifer in the affected areas ranges from 300 to 1,400 feet. Most individual water supply wells in the coal seam do not exceed 600 feet and have up to 300 feet of available drawdown. Well pumps typically are set between 50 to 200 feet below the static water level in the well. Significant impact in terms of well yield or availability is likely to be an issue only if the drawdown exceeds approximately 20 to 30 percent of available drawdown at any given location. This area would tend to coincide with the area of drawdown in excess of approximately 100 feet. The decreased head against which the well pump has to operate may cause the pump discharge to decrease. However, if sufficient available drawdown remains in the well, yield may be restored by installing a larger pump. In cases where the drawdown causes the water level in a well to drop below the intake of the pump, the pump may have to be lowered in the well. Even where yield is restored, the well may be too gassy to pump or use.

Water level changes in wells are not expected to be as significant in the aquifers above or below the coal because the coal is confined both above and below by low permeability claystone layers over most of the PRB. Examination of drilling and geophysical logs from CBM wells shows that the coal seams are separated from sands in the overlying Wasatch Formation by relatively continuous, low-permeability claystone and siltstone confining layer that ranges in thickness from 11 to 363 feet. In most cases, the claystone confining unit is at least 30 feet thick. The large variation in thickness is mostly a function of whether any significant sands exist in the lower part of the Wasatch Formation at a given location. This claystone unit restricts hydraulic communication between the coal and the overlying Wasatch sands. A significant period of time (typically several years) will likely pass before drawdown effects due to pumping groundwater from the

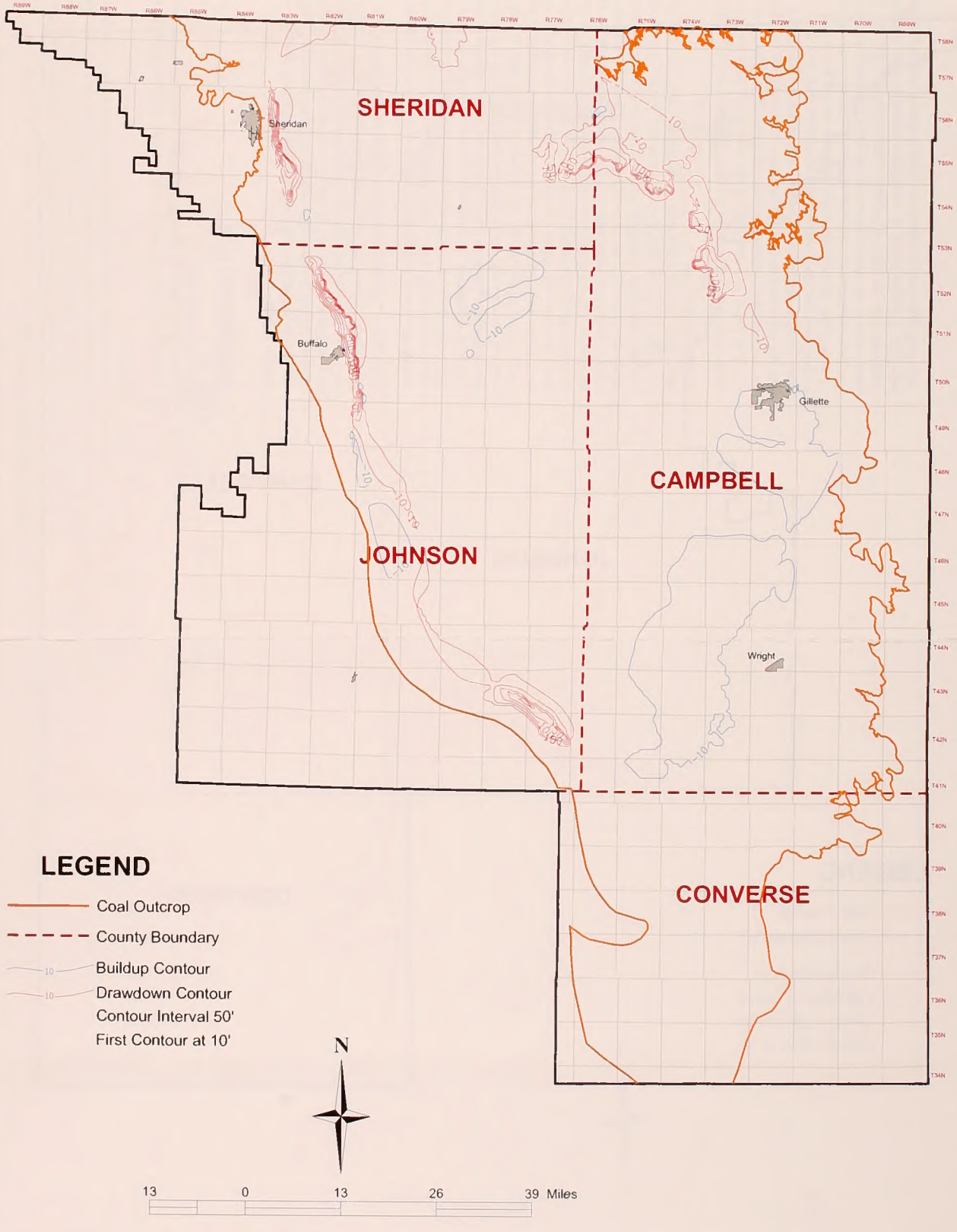


POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 4-8
MODELED WATER LEVEL CHANGE FOR SHALLOW WASATCH SAND-YEAR 2005

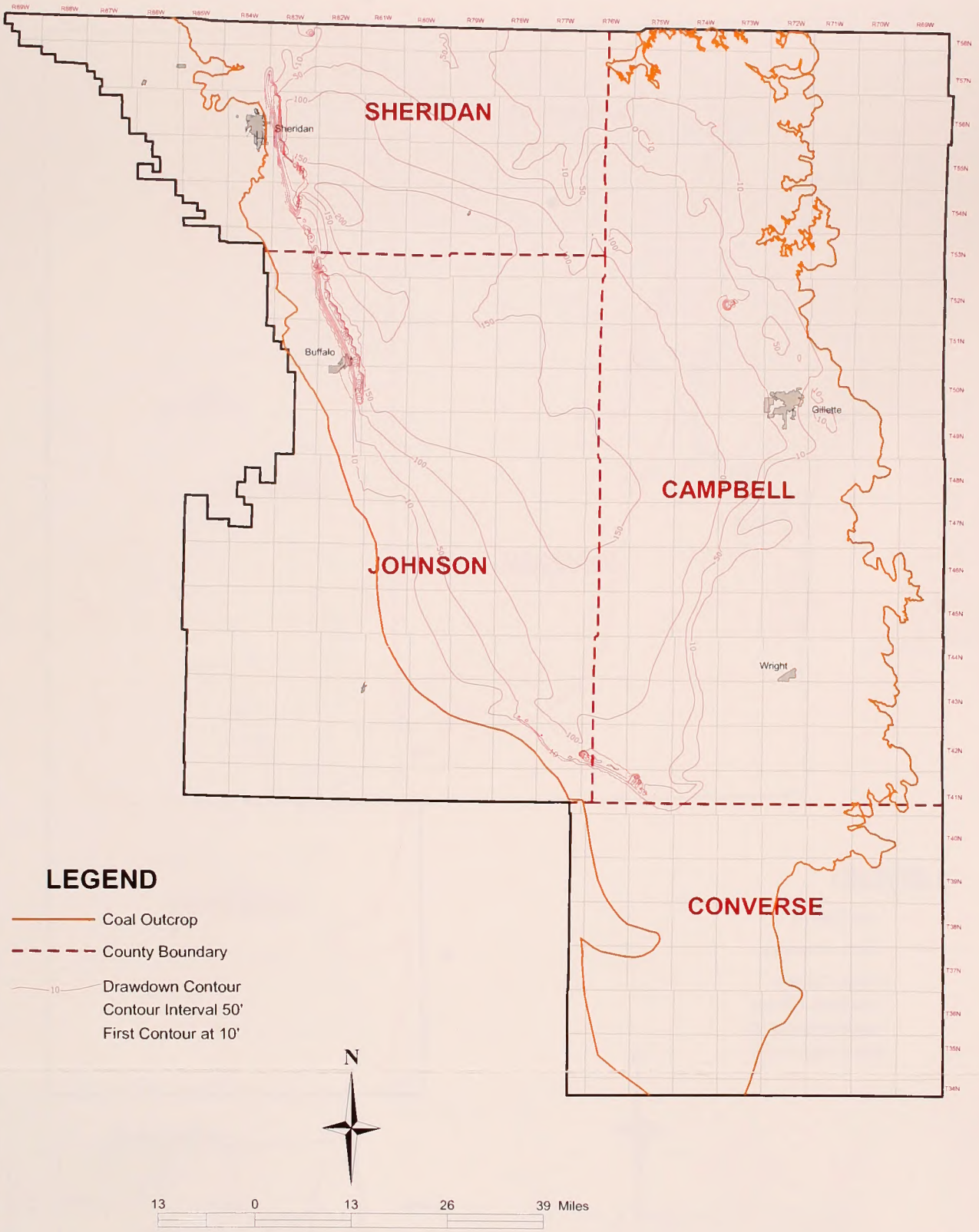
MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP2.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.



POWDER RIVER BASIN OIL/GAS EIS PROJECT	
FIGURE 4-9 MODELED WATER LEVEL CHANGE FOR SHALLOW WASATCH SAND- YEAR 2012	
MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP2.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.

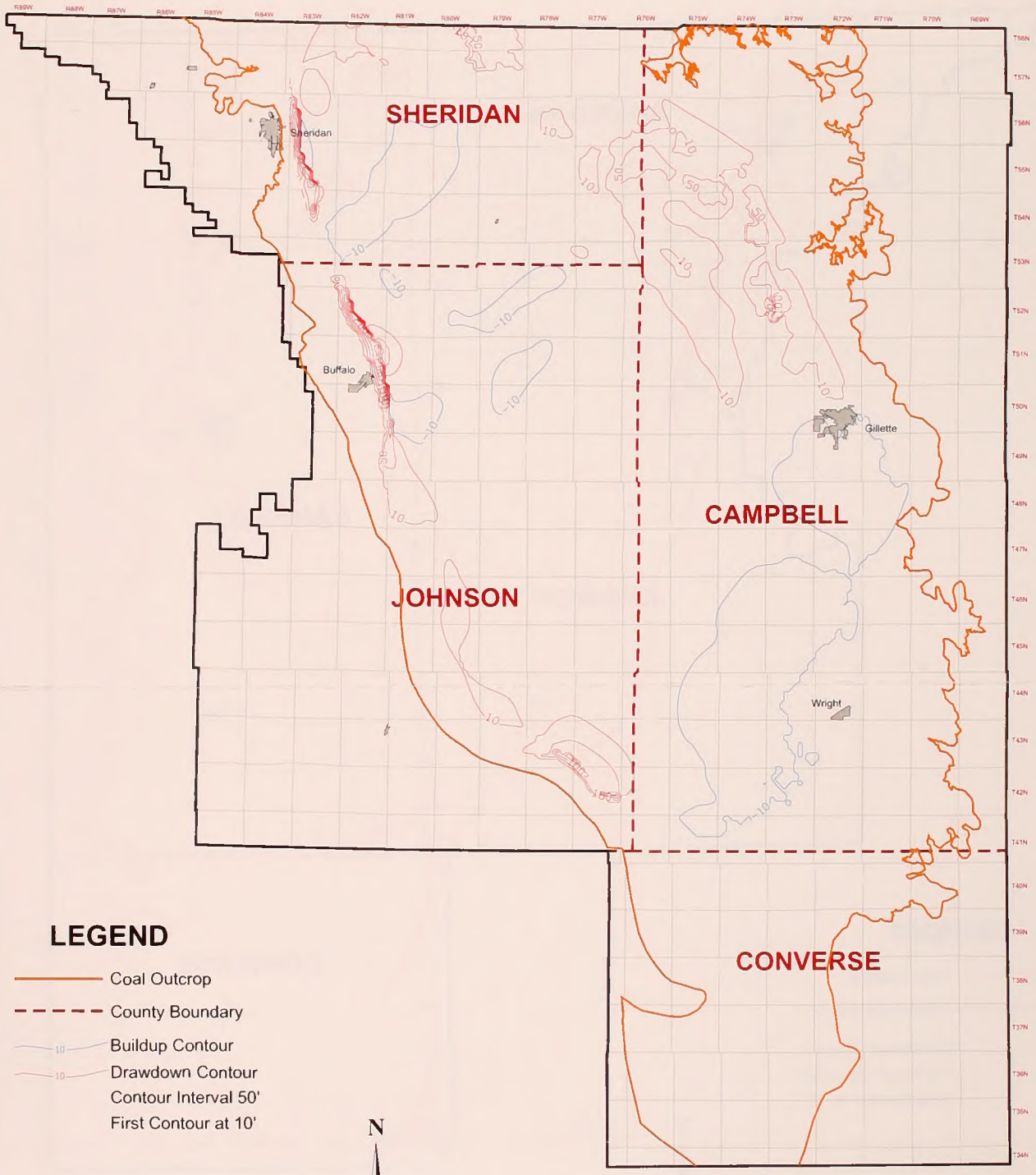


POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 4-10
MODELED WATER LEVEL RECOVERY IN DEEP WASATCH SAND-YEAR 2030

MODEL RUN: From 1999-2224 (11-25-01)	
Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP2.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.



POWDER RIVER BASIN OIL/GAS EIS PROJECT

FIGURE 4-11
MODELED WATER LEVEL RECOVERY IN SHALLOW WASATCH SAND- YEAR 2030

MODEL RUN: From 1999-2224 (11-25-01)

Date: 12/20/01	Drawing File: 1011 PDEIS BASE MAP2.DWG
Scale: As Noted	DRAWN BY: ETC

Transverse Mercator Projection
1927 North American Datum
Zone 13
Data Source: Applied Hydrology, Inc.

coal are apparent in the overlying Wasatch sands. Although, as noted in Chapter 3, the integrity of the confining layer may be compromised locally by water supply wells screened through both the coal and the overlying sands, by deteriorating well casings, or by poorly plugged oil and gas wells or exploratory drill holes, isolated local influences do not affect regional results.

Projected drawdown in the Wasatch sands may affect users of Wasatch aquifer water. The water well agreement would provide sufficient protection to landowners if impacts were to occur on federal mineral ownership lands and non-federal lands for which the agreement is in place.

The model also indicates that the sand units within the lower members of the Fort Union Formation may experience water levels declines of up to 50 feet where intensive CBM production occurs in the overlying Fort Union Formation coals. This is unlikely to noticeably affect the utilization of these aquifer units for water supply. For individually impacted water wells, refer to the "Mitigation Measures" section. A standard agreement has been developed by CBM operators to monitor and mitigate impacts to individual water well owners that are caused by CBM operations. A copy of this water well agreement format is contained in Appendix G. Wyoming Statute 41-3-933 specifically states that groundwater levels and artesian pressures in water wells are not guaranteed.

Artesian flow has been reported in wells located near the Powder River, where the hydraulic head from the deep coal aquifer extends to the surface. Groundwater has been discharging in this area, in part to artesian wells. A reduction in hydraulic head within the coal aquifer (projected to occur during CBM development under Alternative 1) likely would reduce or eliminate artesian flow in water wells. Artesian flow in wells likely would not recover until hydraulic head in the coal aquifer recovers sufficiently following CBM development.

Methane Emission

Withdrawal of water from the coal aquifer during CBM development can depressurize the coal aquifer and induce methane release into nearby water wells completed in the coal aquifer. Individual coal aquifer well users may experience increased methane emissions if their wells fall within an area experiencing noticeable aquifer depressurization.

Records of first indications of methane production in monitoring wells that have experienced water level drops due to mining indicate that methane emission from the coal can occur with as little as 50 feet of head drop (Belle Ayr Mine groundwater monitoring data). Consequently, coal wells within the predicted 50-foot drawdown area may be susceptible to this impact. Methane emissions by a well pose a potential explosive safety hazard, particularly if gases can build up in an enclosed space. In areas within two miles of operational CBM well fields, well houses and basements should be well ventilated and periodically checked for methane gas.

Groundwater Quality

Groundwater quality within the regional aquifer systems of the PRB would not be noticeably affected under Alternative 1. Any noticeable effects on groundwa-

ter quality would be expressed as effects on aquifers that would be recharged during CBM development or existing springs (which emanate from the ground and may contain groundwater derived from these aquifers).

Water Wells

Where CBM wells are drilled in close proximity to existing water wells, immediately after the drilling and completion of the CBM wells, water quality in existing water wells may be temporarily affected. The WSEO has received reports of increased sediment, fines, and water odor appearing in wells where water is being produced from a zone shallower than the target coal. These effects were reported to be temporary, clearing up after a period of time.

Aquifers

Effects on groundwater quality within the Quaternary alluvial aquifers could occur, unless the quality of CBM produced water discharging to surface drainages or infiltrating alluvial aquifers is strictly controlled. CBM produced water is typically slightly alkaline, hard sodium bicarbonate or sodium sulfate type water that may be enriched in some constituents such as iron, manganese, or barium. Surface waters occurring at lower elevations in the PRB typically are hard, alkaline sodium sulfate-type waters (Chapter 3). NPDES permits, required for the surface discharge of produced water, limit concentrations of produced water constituents of concern to levels that would not cause degradation of surface water quality or alluvial aquifer quality.

The effects of CBM produced water on alluvial aquifers in the Middle Powder River sub-watershed would need to be analyzed site-specifically by BLM at the APD/POD level of analysis to ensure alluvial aquifer quality would not be degraded by CBM development activities. The Middle Powder River sub-watershed is the only portion of the Project Area where documentation exists (Chapter 3) that TDS levels in CBM produced water (2,977 mg/L), on average, noticeably exceed TDS levels in natural stream flows (1,550 mg/L).

Very little effect on groundwater quality within Lower Tertiary aquifer systems of the PRB would be expected under Alternative 1. The quality of the water infiltrating the surface during CBM development, and recharging the Wasatch and Fort Union aquifers would not be expected to be lower than the existing groundwater within these aquifers. Water quality in the Wasatch aquifer is quite variable (Chapter 3) and would be unlikely to be noticeably affected by CBM development. Since CBM produced water recharging the Fort Union coal aquifer was produced from this same aquifer, water quality in the Fort Union aquifer also would be unlikely to be noticeably affected by CBM development. No contaminants would infiltrate the surface or reach these aquifers.

Existing Springs

The sources and existing natural quality of spring waters have not been studied throughout the Project Area. However, spring water chemistry likely would be similar to the characteristics of a spring's source aquifer, shallow infiltrated water, or surface water. Under Alternative 1, CBM produced water could be mixed with shallow infiltrated water or surface water from natural sources.

The coal aquifer, which yields CBM produced water, also is the source aquifer for some springs in the Project Area. Contributions of CBM produced water to spring flows emanating from the coal aquifer are not likely to degrade the spring water quality, since characteristics and constituent concentrations would be similar.

Infiltration of CBM produced water mixed with natural stream flows, and subsequent discharge of these waters at springs, likely would not have noticeable effects on the quality of spring water. Springs having water chemistry similar to surface waters likely would not have noticeable effects on water quality under Alternative 1. The effects of CBM produced water on springs in the Middle Powder River sub-watershed would need to be analyzed site-specifically to ensure spring water quality would not be degraded by CBM development activities.

CBM operations are not expected to have any impact on the water quality of Moyer Springs because discharge water is not likely to encroach on the recharge area of the spring. Water from Moyer Springs is of calcium sulfate chemical type, with total dissolved solids concentrations in the 1,000 mg/l to 2,000 mg/l range (Hodson et al. 1973). CBM produced water likely would be of equal or better quality. Therefore, even if some CBM discharge water did recharge Moyer Springs, CBM operations should not adversely affect its water quality.

Groundwater Flow Systems

The groundwater resources of the PRB are vast, and regional flow within and out of the PRB would not be noticeably affected under Alternative 1. Any noticeable effects on local groundwater flow systems would be expressed as effects on existing springs or groundwater discharge areas.

Existing Springs

The public has expressed concern regarding the potential effects of CBM development on springs issuing from clinker outcrops, such as the Moyer Springs located north of Gillette in Sec. 30 T.51N. R.71W. Moyer Springs is located at the base of an exposed clinker deposit in the outcrop area of the Roland-Smith coal seam. Recharge of the springs is through surface infiltration and lateral movement of water from adjacent clinker and alluvium. The springs issue along a low-permeability zone at the contact between the clinker and the coal. Large areas of clinker are exposed northeast and southeast of Moyer Springs (Williams 1978). This exposure allows a large amount of recharge to the clinker by infiltration of rainfall and snowmelt. Hodson et al. (1973) reported a flow of 200 gallons per minute from Moyer Springs.

No decrease in spring flows would be anticipated under Alternative 1 where the issuance of springs results from flow along a near-surface zone of low permeability intercepting the surface. Many springs in the Project Area, including Moyer Springs, represent this type of occurrence. A contact having low permeability inhibits flow between the clinker and the coal. The presence of a low-permeability zone between the clinker and the coal results in water in the clinker being channeled to the spring rather than recharging the coal. A decrease in recharge to the spring (not projected to occur under Alternative 1) could cause a reduction in flow for this type of spring.

The natural discharge of springs in the Project Area potentially could be affected by a reduction in the hydraulic head in an aquifer unit, if the aquifer experiencing the reduction in hydraulic head were the spring's source aquifer. Spring flow could decrease or stop under these conditions. Spring flow likely would not recover until the hydraulic head in the coal aquifer recovers sufficiently following CBM development. Springs issuing from the Wasatch sands into surface drainages may experience increased flows during the time period that CBM produced water is recharging shallow aquifers.

The use of infiltration impoundments or flow-through stock reservoirs during surface discharge associated with CBM development could increase existing spring flows where a near-surface zone of low permeability intercepts the surface, unless these water handling facilities are sited to minimize this potential effect. Avoidance of sites where a zone of low permeability intercepts the surface downhill or downgradient from an area where considerable infiltration of CBM produced water is occurring, would minimize the potential for shallow infiltrated water to increase the recharge or spring flow of existing springs.

Only minimal infiltration would be anticipated where containment ponds or reservoirs constructed in upland areas would be used to handle CBM produced water. It is unlikely that existing spring flows would be affected near properly engineered and constructed containment impoundments.

Groundwater Discharge Areas

Groundwater has been discharging to the surface in many areas near the Powder River, where the hydraulic head from the deep coal aquifer intercepts the surface, and flow along the natural groundwater gradient is toward the river. A reduction in hydraulic head within the coal aquifer, projected to occur during CBM development under Alternative 1, likely would reduce groundwater discharge and base flows in surface drainages within the Powder River's drainage basin. Groundwater discharge likely would not recover until the hydraulic head in the coal aquifer recovers sufficiently following CBM development. The discharge of CBM produced water to surface drainages that feed into the Powder River would mitigate this projected reduction in natural groundwater discharge. The effects of surface discharge of CBM produced water to the Powder River's drainage basin would need to be analyzed site-specifically by BLM at the APD/POD level of analysis to ensure that appropriate water balance and quality would be maintained during CBM development activities.

Only minimal infiltration would be anticipated where containment ponds or reservoirs constructed in upland areas would be used to handle CBM produced water. It is unlikely that new springs would develop or shallow infiltrated water would resurface near properly engineered and constructed containment impoundments.

The use of infiltration impoundments or flow-through stock reservoirs during surface discharge associated with CBM development could cause new springs to develop where a near-surface zone of low permeability intercepts the surface, unless these water handling facilities are sited to minimize this potential effect. Avoidance of sites where a zone of low permeability intercepts the surface downhill or downgradient from an area where considerable infiltration of CBM

produced water is occurring, would minimize the potential for shallow infiltrated water to resurface.

One detailed model study performed for the LX Bar drainage (AHA 2001d) showed that the potential contributions to surface flows from increased groundwater discharge would be much less than one cfs, if all CBM produced water in the LX Bar drainage were held in infiltration impoundments. However, the same detailed model study also showed that the potential rise in shallow groundwater level would be up to ten feet near impoundments, if all CBM produced water in the LX Bar drainage were held in infiltration impoundments.

In many areas where infiltration impoundments could be constructed, the current water table may be less than ten feet below the surface. In these areas the increase in water level may be exhibited as groundwater discharge to the surface, standing water in areas not previously displaying this condition, or as wetland development, unless the percentage of CBM wells having produced water held in infiltration impoundments is carefully controlled. The effects of impoundment and infiltration of CBM produced water would need to be analyzed site-specifically to ensure that water table and groundwater discharge effects are carefully balanced or mitigated during CBM development activities.

Alternative 2A

Under Alternative 2A, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences in recharge that would occur based on differences in water handling options, (discussed below), the effects on groundwater resources would be similar to those described under Alternative 1.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations was obtained from the model output for each of the affected sub-watersheds (Table 2-8). This modeled water production would be managed according to the water handling options identified for each sub-watershed under Alternative 2A (Table 2-21). The net recharge is calculated based on the percentage of the produced water handled by each method and the projected conveyance loss. The calculated net recharge volume, on a year-by-year basis, was divided by the projected CBM development area within each sub-watershed to obtain an equivalent recharge rate for the area, in inches per year. Depending on the water handling practices used within each sub-watershed, under Alternative 2A an estimated 55 to 66 percent of the pumped water would be recharged to the groundwater system as a result of infiltration along creeks and below impoundments, or direct injection. This recharge under Alternative 2A is compared below to the values input into the model under Alternative 1.

Alternative 2A involves different handling of the water produced by CBM operations in certain sub-watersheds. Depending on the water handling practices used within each sub-watershed, an estimated 70 to 85 percent of the groundwater produced from CBM operations would be released to surface drainages or impoundments. The proportion of water handled by infiltration impoundment would

be emphasized under Alternative 2A. Under Alternative 2A, less CBM produced water would be discharged to surface drainages than under Alternative 1. More CBM produced water would be handled using infiltration impoundments, containment impoundments, land application disposal (LAD), and injection than under Alternative 1. Also, under Alternative 2A, there would be a five percent reduction from Alternative 1 in the produced water handled using LAD in the Crazy Woman Creek sub-watershed, with a corresponding increase in the produced water handled by injection. In the Salt Creek sub-watershed, surface discharge and some LAD would be replaced by increased use of infiltration or containment impoundments, and injection as preferred water-handling methods.

The change in water handling methods would result in a decrease in infiltration compared to Alternative 1. This decrease would be small, six percent or less, on average, in all sub-watersheds except Salt Creek, where 19 percent less water would infiltrate at the ground surface than under Alternative 1. The projected reduction in surface infiltration, on average, would represent a small fraction of an inch per year in any sub-watershed. This slight change would have a negligible effect on groundwater conditions within the affected drainages. The Crazy Woman Creek and Salt Creek sub-watersheds would have an increased percentage of water management by injection into deeper aquifers (below the coal zone).

Alternative 2B

Under Alternative 2B, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences in recharge that would occur based on differences in water handling options, (discussed below), the effects on groundwater resources would be similar to those described under Alternative 1.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations was obtained from the model output for each of the affected sub-watersheds (Table 2-8). This modeled water production would be managed according to the water handling options identified for each sub-watershed under Alternative 2B (Table 2-22). The net recharge is calculated based on the percentage of the produced water handled by each method and the projected conveyance loss. The calculated net recharge volume, on a year-by-year basis, was divided by the projected CBM development area within each sub-watershed to obtain an equivalent recharge rate for the area, in inches per year. Depending on the water handling practices used within each sub-watershed, under Alternative 2B an estimated 56 to 66 percent of the pumped water would be recharged to the groundwater system as a result of infiltration along creeks and below impoundments, or direct injection. This recharge under Alternative 2B is compared below to the values input into the model under Alternative 1.

Alternative 2B involves different handling of the water produced by CBM operations in certain sub-watersheds. Depending on the water handling practices used within each sub-watershed, an estimated 70 to 85 percent of the groundwater produced from CBM operations would be released to surface drainages or im-

poundments. The proportion of water handled by infiltration impoundment would be emphasized, but would have an upper limit under Alternative 2B, and active treatment for CBM produced water by reverse osmosis or other suitable methods would be included as a water handling method. Under Alternative 2B, less CBM produced water would be discharged to surface drainages than under Alternative 1. More CBM produced water would be handled using infiltration impoundments, containment impoundments, land application disposal (LAD), and injection than under Alternative 1. Also, under Alternative 2B, there would be a five percent reduction from Alternative 1 in the produced water handled using LAD in the Crazy Woman Creek sub-watershed, with a corresponding increase in the produced water handled by injection. In the Salt Creek sub-watershed, surface discharge and some LAD would be replaced by increased use of infiltration or containment impoundments, and injection as preferred water-handling methods.

The change in water handling methods would result in a decrease in infiltration at the ground surface. This decrease would be small, six percent or less, on average, in all sub-watersheds except Salt Creek, where 19 percent less water would infiltrate at the ground surface than under Alternative 1. The projected reduction in surface infiltration, on average, would represent a small fraction of an inch per year in any sub-watershed. This slight change would have a negligible effect on groundwater conditions within the affected drainages. The Crazy Woman Creek and Salt Creek sub-watersheds would have an increased percentage of water management by injection into deeper aquifers (below the coal zone).

Alternative 3

Alternative 3 (No Action) assumes that no new Federal CBM wells would be completed, except for potential drainage situations. This would result in a substantial reduction in projected new CBM wells, from 39,367 to 15,458. Except for the differences discussed below, the effects on groundwater resources would be similar to those described under Alternative 1.

Under Alternative 1, the largest numbers of new Federal CBM wells would be drilled in the Upper Powder River and Upper Belle Fourche River sub-watersheds (24,898 of 39,367 projected wells under Alternative 1). The exclusion of federal wells from these sub-watersheds under Alternative 3 represents a 77 percent reduction in the Upper Powder River sub-watershed (14,531 wells) and a 43 percent reduction in the Upper Belle Fourche River sub-watershed (2,531 wells). The percentage reduction in wells also would be great in the Middle Powder River sub-watershed, where the reduction would be 79 percent (or 757 wells). Over 1,000 wells also would be eliminated in each of the following sub-watersheds: Crazy Woman Creek (1,986 wells); Clear Creek (1,265 wells); Little Powder River (1,076 wells); and Antelope Creek (1,041 wells). Relatively lower percentage reductions in wells would occur in the Upper Tongue River sub-watershed (17 percent) and in the Clear Creek sub-watershed (34 percent).

Although water production would decline substantially in all sub-watersheds under Alternative 3, the percentage reduction in water production, compared with Alternative 1, would be less than the reduction in wells shown in Chapter 2. Un-

der Alternative 3, individual wells would have to produce more water to maintain sufficient drawdown and allow methane to be produced.

Water-handling options would be same as under Alternative 1. Depending on the water-handling practices used within each sub-watershed, an estimated 80 to 95 percent of the groundwater produced from CBM operations would be released to surface drainages or impoundments.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations was projected for each of the affected sub-watersheds (Table 2-32). This projected water production would be managed according to the water-handling options identified for each sub-watershed under Alternative 1 (Table 2-9). The projected net recharge is calculated based on the percentage of the produced water handled by each method and the projected conveyance loss. Depending on the water handling practices used within each sub-watershed, under Alternative 3 an estimated 55 to 68 percent of the pumped water would be recharged to the groundwater system as a result of infiltration along creeks and below impoundments, or direct injection.

The extent of drawdown in the coal units would change, compared to Alternative 1. The greatest change would occur in the sub-watersheds with the largest percentages of Federal wells. The areal extent of the 10-foot drawdown contour would tend to decrease in the vicinity of large concentrations of Federal wells that were projected to be drilled under Alternative 1, for example in the Upper Powder River sub-watershed. It is less likely that State and Fee wells would be developed around the large Federal blocks unless there would be enough wells to maintain adequate drawdown and produce methane.

With the decline in water production, the total quantity of produced water that recharges the shallow bedrock and alluvium would diminish proportionately. The areal extent of recharge would be reduced the most in the Upper Powder River, Upper Belle Fourche River, and Crazy Woman Creek sub-watersheds because these areas would have featured the largest numbers of new Federal CBM wells. The projected changes in water levels in the shallow Wasatch sands would be less that those projected under Alternative 1, in approximate proportion to the difference in water production and consequent recharge.

Under Alternative 3, the change in water levels within the deep Wasatch sands, compared with Alternative 1, would be noticeable in fewer areas. In areas that would have had a high concentration of federal wells under Alternative 1, the extent of drawdown in the coals could be considerably less due to non-development, resulting in less drawdown in overlying sands. However, the regional effect on deep Wasatch sands would be relatively minor, due to the sands' isolation from the pumped coals, making the differences in projected impacts between Alternatives 1 and 3 less apparent. The effects on shallow Wasatch sands would be similar to the effects on deep Wasatch sands.

Cumulative Effects

Regionally, the different PRB coal zones merge, split, and pinch out laterally in complex patterns (Flores 1999, Flores et al. 1999). Coal zone aquifers within the Project Area occur as layers that, individually, are continuous only over an average distance of ten miles or so. While regional groundwater flow toward the north does occur, this flow is interrupted where coal aquifers are discontinuous, and groundwater is discharged in local flow systems. Where coal aquifers are discontinuous, flow in local groundwater systems (bedrock, alluvial, and clinker) appears to dominate over the flow in a regional system (Rankl and Lowry 1990). Most of this local groundwater discharge from bedrock aquifers occurs above stream level and is lost due to evapotranspiration or consumed as soil moisture, and does not make a very noticeable contribution to surface drainages.

The areal extent and magnitude of drawdown effects on coal zone aquifers and overlying or underlying sand units in the Wasatch Formation also would be limited by the discontinuous nature of the different coal zones within the Fort Union Formation and sandstone layers within the Wasatch Formation. Where a coal zone aquifer or sandstone layer pinches out laterally, drawdown effects also would be interrupted somewhat, although leakage from nearby layers would continue to occur. This discontinuous nature of the different coal zones would tend to limit the areal extent of drawdowns occurring in Montana, outside the Project Area, that are associated with CBM development in the PRB within Wyoming.

Computer modeling of groundwater resources could not capture the level of subsurface detail actually existing in the PRB. In order to develop a reasonable model for this analysis, hydrogeologic layers included in the model assumed coal beds are more continuous and have more uniform thicknesses than those actually occurring in the PRB. The drawdown effects on coal zone aquifers and sandstone layers predicted by the model represent the maximum areal extent and magnitude of drawdowns, assuming continuous layers of uniform thickness. Drawdowns in discontinuous layers likely would be limited by the continuous areal extent of the layer. Where coal aquifers are being mined, such as in the coal area near the State line, the mine area is established as a drain node in the model. A quantitative estimate of CBM-associated drawdown near a mine area is difficult to predict.

Alternative 1

The cumulative impacts on groundwater resources from activities associated with CBM development and those impacts associated with coal mining have been included in the groundwater model and impact analysis described earlier in this chapter under Groundwater. Reasonably foreseeable groundwater conditions could not be considered separately for proposed CBM development. Therefore, the analysis included the impacts of existing and reasonably foreseeable CBM development and mining. Reasonably foreseeable coal mining activities, as depicted in mine plans, and existing coal mine effects on groundwater resources were incorporated within the groundwater model. Projected CBM development and CBM development existing or authorized prior to this analysis also were incorporated within the groundwater model. Modeled water production, shown in Table 2-8 and already discussed in this chapter, represented total water produc-

tion for existing/authorized CBM wells and CBM wells projected under Alternative 1.

Northeast of Sheridan, Wyoming the model projects some effects of the proposed Project extending into Montana for a short distance, however these projections near the Montana-Wyoming State line are based on very limited data. Drawdowns of approximately 100 feet in the Fort Union coal zone are projected to extend one to three miles into Montana The model projects coal zone recovery to a 25 foot drawdown by 2030 for most areas in Montana affected by the Project. In the same area, the model projects a ten foot drawdown in the deep Wasatch sands extending approximately 10 miles into Montana, and a 50 foot drawdown extending approximately three miles into Montana. The model projects deep Wasatch sand recovery to a 10-foot drawdown by 2030. The model projects a 10-foot drawdown for shallow Wasatch sands extending approximately six miles into Montana, and a 10-foot buildup in shallow Wasatch sands for a small area extending approximately two miles into Montana. A 50-foot drawdown within the shallow Wasatch sands is projected to extend two to three miles into Montana in a small area. The model projects shallow Wasatch sand recovery to a ten-foot drawdown for most affected areas in Montana by 2030.

Cumulatively, groundwater would be removed from the coal aquifers underlying the Project Area, temporarily reducing or eliminating the hydraulic pressure head in the coal. An estimated 55 to 68 percent of the groundwater removed would infiltrate the surface and recharge the shallow aquifers above the coals. Pressure redistribution within the coals following termination of water production would cause hydraulic pressure head to recover within approximately 65 feet or less of pre-project levels, within approximately 15 years after the project ends. Complete recovery of water levels likely would take many years. This reduction in hydraulic pressure head likely would cause a slight reduction in regional groundwater discharge to surface drainages within the Powder River drainage system, including drainages downstream of the Project Area, in Montana. However, there would be a corresponding slight increase in surface flows downstream of the Project Area resulting from CBM surface discharges and groundwater discharges to surface drainages from shallow aquifers.

Wasatch aquifers overlying the coals also would be affected by development activities. As the coal is de-pressurized by water removal during mining or CBM development, water contained in deep Wasatch sands would leak into the coals. Water levels in the deep Wasatch sands would be lowered, but not as much or as quickly as the drawdown that would occur in the coal. Water levels in the deep Wasatch sands also would recover following development. Recovery to within approximately 35 feet of pre-operational levels would occur in approximately 17 years. Complete recovery of water levels likely would take many years. Water levels (i.e., the water table) in shallow Wasatch sands also would be lowered during development activities and also would recover after water production ends. In some areas, water levels in very shallow Wasatch sands likely would rise initially, up to 10 feet; before being drawn down due to enhanced recharge from infiltration of CBM produced water.

Differentiation of impacts between CBM development activities and coal development activities is presented below. There are some similarities and some differences in the impacts associated with mining and CBM development.

Effects on the Coal Aquifer

Both mining and CBM development result in partial removal of the water from the coal seam. In mining, the coal is removed so that impacts to the coal aquifer in the areas of mining are considerable. Immediately adjacent to active mine pit areas, the water from the coal aquifer will drain into the pit and become dewatered. The extent of coal aquifer dewatering and de-pressurization associated with mining is largely dependent on the continuity of the coal in the vicinity of the mine and its overall permeability (a function of fracturing). In areas of high coal permeability, which tend to coincide with major fracture trends, the extent of drawdown may be several miles. Areas of limited coal drawdown related to mining are associated with lower permeability or less fracturing in the coal.

During active CBM development, pumping groundwater from the coal induces depressurization. Pumping removes water (and methane) from the coal but leaves the coal itself essentially undisturbed. Depressurization within the coal caused by CBM development will be more widespread than that due to mining because CBM development will cover a much larger area than mining. Mining is limited to an area within two to three miles of the coal outcrop because of overburden-coal strip ratios. CBM development is projected to cover most of the Project Area.

Impacts to Aquifers Stratigraphically Above the Coal

The sand aquifers of the Wasatch Formation are hydrologically separated from the coal zone within the Fort Union Formation by low permeability claystones. During mining, the shallower aquifers (the overburden) must be removed to access the coal. Impacts to these aquifers in mined areas are considerable. Immediately adjacent to active mine pit areas, the Wasatch sands intercepted by excavations may drain into the pit and become dewatered. The areal extent of Wasatch aquifer dewatering associated with mining is largely dependent on the continuity of the sand units occurring near the mine, and whether these sand units are intercepted by mining activities. There are many examples of overburden monitoring wells, completed in relatively isolated sand units, showing very little influence from nearby mining. Drawdown in the coal aquifer, induced by mining, in turn, induces vertical leakage from the overlying Wasatch sands, contributing to drawdown in these sands.

During CBM development, the Wasatch sand aquifers would not be directly impacted by excavations or surface disturbing activities. Leakage from the Wasatch sands into the coal would be enhanced by CBM development. Due to limited hydraulic communication between the coal and the overlying Wasatch sands, a considerable period of time (typically several years) may pass before noticeable drawdown of the sands occurs. The areal extent of drawdowns in the Wasatch sands resulting from CBM development would be much greater than the drawdown areas in the sands caused by mining.

Changes in Infiltration Rates and Recharge

During mining, the overburden (including Wasatch sand aquifers) and coal aquifers are removed and replaced with backfill material (spoils). Infiltration and recharge through the spoils are likely to be higher than in the original undisturbed materials. During CBM development, the aquifers would remain essentially undisturbed and the infiltration and recharge mechanisms also would be unchanged. Water discharged to the surface from CBM operations would increase recharge to alluvial aquifers and underlying Wasatch sands.

Changes in Groundwater Quality

After mining, the coal and Wasatch sand aquifers are replaced with mine spoils having the potential to change the quality of groundwater. During CBM development, water removed from the coal would recharge alluvial and Wasatch sand aquifers, and may cause small changes in groundwater quality.

Discharge of Produced Waters

Both mining and CBM development result in water collection and discharge to surface drainages. Mine inflow water is first stored in sediment ponds to reduce sediment picked up in the pit. Much of this water is used for dust suppression. The discharge water from sediment ponds potentially would have higher TDS values and be of lower quality due to sediment mixing and concentration by evaporation. CBM discharges are essentially sediment-free (as produced from CBM wells), although discharge to surface drainages can increase sediment loading caused by increased stream erosion.

Fort Union Aquifers Underlying the Coal Zone

Mining may affect aquifers underlying the coal zone by potentially influencing recharge water quality. Groundwater withdrawals from lower aquifers for mine use also may affect these aquifers. CBM development may affect lower aquifers by inducing upward leakage from them into the coal during coal depressurization. These cumulative influences were included in the groundwater model.

Moyer Springs

The potential impact to Moyer Springs flows by proposed surface mining has been recognized, as removal of the Wasatch Formation and alluvial overburden during mining operations may decrease recharge to the spring. Accordingly, the Dry Fork Mine Permit requires Dry Fork Coal Company to protect the clinker aquifer that feeds Moyer Springs.

Alternative 2A

The cumulative impacts on groundwater resources would be similar to those described under Alternative 1, except as noted below.

Projected CBM development and CBM development existing or authorized prior to this analysis also were incorporated within the groundwater model. Modeled water production, shown in Table 2-8 and already discussed in this chapter, represented total water production for existing/authorized CBM wells and CBM wells projected under Alternative 2A.

Cumulatively, groundwater would be removed from the coal aquifers underlying the Project Area, temporarily reducing or eliminating the hydraulic pressure head in the coal. An estimated 55 to 66 percent of the groundwater removed would infiltrate the surface and recharge the shallow aquifers above the coal.

Alternative 2B

The cumulative impacts on groundwater resources would be similar to those described under Alternative 1, except as noted below.

Projected CBM development and CBM development existing or authorized prior to this analysis also were incorporated within the groundwater model. Modeled water production, shown in Table 2-8 and already discussed in this chapter, represented total water production for existing/authorized CBM wells and CBM wells projected under Alternative 2B.

Cumulatively, groundwater would be removed from the coal aquifers underlying the Project Area, temporarily reducing or eliminating the hydraulic pressure head in the coal. An estimated 56 to 66 percent of the groundwater removed would infiltrate the surface and recharge the shallow aquifers above the coals.

Alternative 3

The cumulative impacts on groundwater resources would be similar to those described under Alternative 1, except as noted below.

Projected CBM development and CBM development existing or authorized prior to this analysis also were incorporated within the groundwater model. Modeled water production, shown in Table 2-32 and already discussed in this chapter, represented total water production for existing/authorized CBM wells and CBM wells projected under Alternative 3.

Cumulatively, groundwater would be removed from the coal aquifers underlying the Project Area, temporarily reducing or eliminating the hydraulic pressure head in the coal. An estimated 55 to 68 percent of the groundwater removed would infiltrate the surface and recharge the shallow aquifers above the coals.

Surface Water

Surface water resources could be affected by:

- Erosion and degradation of the drainage network;
- Increased sedimentation;
- Surface water quality changes; and
- Changes in suitability for beneficial use

The effects of the project on surface water quantity, quality, and existing uses under Alternative 1, Alternative 2A, Alternative 2B, and Alternative 3 are discussed below.

For the purposes of this analysis, surface water flow is expressed in cfs. The water produced from wells is expressed in gpm. One cfs is equivalent to 448.83 gpm. Large flows or volumes of water are expressed as acre-feet. One acre-foot is equivalent to 43,560 cubic feet, or 325,851 gallons.

Alternative 1

Surface Water Quantity

For analysis purposes, CBM water production modeled in the groundwater impact analysis and shown in Table 2-8 was used to calculate the volume of CBM produced water that would be assimilated under Alternative 1. Each well would have a seven-year life span. Based on model projections of water production for new wells and compilation of water production data for existing wells, the total water production for 39,367 new producing wells and 12,077 existing wells would be approximately 4.4 million acre-feet over the life of the project. The 39,367 new wells would be drilled in the Project Area over a ten-year period, with approximately 5,000 wells being drilled each year for the first six years of the project life. The existing wells include wells already drilled, some of which are producing, and those wells already authorized and projected for completion by 2002, but not necessarily producing. For the purpose of this analysis, it is assumed that all of the 12,077 existing wells have their first year of water production prior to 2002, and that water production for the last of the existing wells to be drilled ends after 2007. Water production from the last of the new wells to be drilled is assumed to conclude in 2017.

Under Alternative 1, CBM produced water flows would be handled through direct discharge to surface drainages, passive treatment prior to surface discharge, discharge to upland and bottomland infiltration impoundments, discharge to containment impoundments, and injection. The projected distribution of water handling methods under Alternative 1 is summarized in Table 2-9. The percentage of water handled by each of these options as a percentage of the total water production is summarized in Table 4–1. The majority of the produced water would be gathered and discharged to the surface, or gathered for discharge into shallow infiltration impoundments. CBM produced water flows discharged to the surface would be distributed to an estimated 4,800 discharge locations, and discharged under the terms of NPDES permits issued by the WDEQ. The discharge at each outfall would average 10 gpm, or approximately 0.02 cfs over the life of the wells producing the water. The maximum discharge at a single outfall, on average, would be approximately 100 gpm, or 0.2 cfs, over the life of the wells producing the water. The maximum flow at each discharge point would represent the average annual runoff from approximately 10 square miles (mi^2) using the 15 acre-feet/mi^2/year described by Lowry et al. (1986).

For the purposes of this analysis, discharge of CBM produced water to surface drainages is assumed to result in a conveyance loss of 80 percent of the total volume of CBM produced water, 82 percent of which would be due to infiltration and 18 percent due to evapotranspiration. These values were derived from studies of surface water losses in creek flows within several drainages of the PRB (Meyer 2000, AHA 2001b). For the purpose of this analysis, the remaining

20 percent of the CBM produced water discharged to surface drainages is assumed to reach the receiving stream at the sub-watershed boundary.

The maximum CBM water volume discharged to the surface annually, prior to conveyance losses, is expected to increase from an estimated 155,000 acre-feet in 2002, to an estimated 222,000 acre-feet, occurring in year 2006. Table 4–4 summarizes the projected annual outflow at each sub-watershed boundary under each Alternative, resulting from surface discharge and accounting for conveyance loss along the stream channels. The projected annual flow of CBM produced water at each sub-watershed boundary would be roughly two percent of the volume of water expected from a 25 year, 24-hour storm event.

Table 4–5 summarizes the projected annual flow of CBM produced water at each sub-watershed boundary as a percentage of the annual stream flow average for each sub-watershed. Under Alternative 1, surface discharge of CBM produced water would account for between 0.02 and 13 percent of the annual average stream flow in each sub-watershed. Increases would be greatest in the Upper Belle Fourche River sub-watershed. Flows attributable to CBM discharges would be greatest during periods of low flow in the receiving streams.

Surface Water Quality

Surface discharge of CBM produced water is authorized by the WDEQ under the terms of a NPDES permit. Each permit specifies effluent limitations established to ensure that numeric water quality criteria contained in Chapter 1 of Wyoming's Water Quality Rules and Regulations for the protection of human health and aquatic life are not exceeded. Constituents of concern for water quality impacts from CBM discharges for which numeric criteria exist include, but are not limited to, arsenic, barium, iron, and manganese. WDEQ recently modified Chapter 1 criterion for these constituents and approved the Barium Antidegradation Policy. New effluent limitations have been established for these constituents which are now basin-specific. Discharges to Class 2 receiving waters will be subject to these effluent limitations and to additional numeric standards contained in Wyoming's Chapter 1 Rules and Regulations. Where effluent limitations cannot be achieved for CBM discharges, treatment of the water may be required. Treatment may be passive, which may include routing the water over a scoria bed to remove constituents such as iron or manganese, or active, which may include ion exchange or reverse osmosis processes for removal of constituents such as barium. With project adherence to NPDES permit requirements, discharges of CBM produced water to surface drainages would not likely result in violations of the Clean Water Act.

Section 20 of Wyoming's Chapter 1 Rules and Regulations incorporates a narrative water quality standard, which specifies that all surface waters with potential for use as an agricultural water supply shall be maintained at a quality which supports the use, and any degradation shall not cause a measurable decrease in crop or livestock production. Federal regulations under 40 CFR 435, Subpart E, also require that discharges of produced water be used for specific agricultural or wildlife uses, and that the produced water should be of acceptable quality to support those uses. Compliance with the federal regulations and documentation of

beneficial use of CBM produced waters would be mandated by the WDEQ under the NPDES program.

Table 4–4 Projected Outflow at Sub-Watershed Boundary for Projected CBM Produced Water Discharge

Sub-Watershed	Total Surface Discharge[1] 2002–2017 (acre-feet)	Conveyance Loss[2] (acre-feet)	Projected Outflow at Sub-Watershed Boundary[3] Annual Average for 2002–2017		
			cfs	gpm	acre-feet/yr
Proposed Action					
Upper Tongue River	243,722	194,977	3.96	1,778	2,867
Upper Powder River	1,239,442	991,553	20.14	9,039	14,582
Salt Creek	510	408	0.01	4	6
Crazy Woman Creek	220,821	176,656	3.59	1,610	2,598
Clear Creek	271,395	217,116	4.41	1,979	3,193
Middle Powder River	60,413	48,331	0.98	441	711
Little Powder River	68,009	54,407	1.11	496	800
Antelope Creek	62,619	50,095	1.02	457	737
Upper Cheyenne River	18,786	15,029	0.31	137	221
Upper Belle Fourche River	195,403	156,322	3.18	1,425	2,299
Alternative 2A					
Upper Tongue River	69,635	55,708	1.13	508	819
Upper Powder River	413,147	330,518	6.71	3,013	4,861
Salt Creek	0	0	0.00	0	0
Crazy Woman Creek	31,546	25,237	0.51	230	371
Clear Creek	77,541	62,033	1.26	566	912
Middle Powder River	23,236	18,589	0.38	169	273
Little Powder River	26,157	20,926	0.43	191	308
Antelope Creek	45,541	36,433	0.74	332	536
Upper Cheyenne River	13,663	10,930	0.22	100	161
Upper Belle Fourche River	195,403	156,322	3.18	1,425	2,299
Alternative 2B					
Upper Tongue River	243,722	146,233	2.97	1,333	2,150
Upper Powder River	661,035	449,504	9.13	4,098	6,610
Salt Creek	0	0	0.00	0	0
Crazy Woman Creek	94,637	60,568	1.23	552	891
Clear Creek	232,624	148,879	3.02	1,357	2,189
Middle Powder River	41,825	26,768	0.54	244	394
Little Powder River	47,083	30,133	0.61	275	443
Antelope Creek	56,926	36,433	0.74	332	536
Upper Cheyenne River	17,078	10,930	0.22	100	161
Upper Belle Fourche River	217,114	173,691	3.53	1,583	2,554
Alternative 3					
Upper Tongue River	93,664	74,931	1.52	683	1,102
Upper Powder River	412,862	330,289	6.71	3,011	4,857
Salt Creek	825	660	0.01	6	10
Crazy Woman Creek	96,816	77,453	1.57	706	1,139
Clear Creek	130,591	104,473	2.12	952	1,536
Middle Powder River	10,315	8,252	0.17	75	121
Little Powder River	38,166	30,533	0.62	278	449
Antelope Creek	20,841	16,672	0.34	152	245
Upper Cheyenne River	11,290	9,032	0.18	82	133
Upper Belle Fourche River	93,678	74,943	1.52	683	1,102

Notes:
1. Extracted from Tables 2-8, 2-9, 2–21, 2–22, and 2–32 in Chapter 2
2. Loss due to infiltration plus evapotranspiration along stream channels
3. Calculated as Total Surface Discharge minus Conveyance Loss

Table 4–5 Projected CBM Annual Outflows Compared with Average Annual Stream Flow by Sub-Watershed

Sub-Watershed	Projected Annual Outflow at Sub-Watershed Boundary[1] (cfs)	Average Annual Stream Flow[2] (cfs)	CBM Discharges as a Percent of Average Annual Stream Flow (percent)
Alternative 1			
Upper Tongue River at State Line near Decker, WY	3.96	463	0.9
Upper Powder River at Arvada, WY	20.14	281	7.2
Salt Creek near Sussex, WY	0.01	44.4	0.02
Crazy Woman Creek at Upper Station near Arvada, WY	3.59	56.7	6.3
Clear Creek nr Arvada, WY	4.41	181	2.4
Middle Powder River at Broadus, MT	0.98	465	0.2
Little Powder River above Dry C near Weston, WY	1.11	22.9	4.8
Antelope Creek near Teckla, WY	1.02	12.6	8.1
Upper Cheyenne River near Riverview	0.31	60	0.5
Upper Belle Fourche River below Moorcroft, WY	3.18	24.6	13
Alternative 2A			
Upper Tongue River at State Line near Decker, WY	1.13	463	0.2
Upper Powder River at Arvada, WY	6.71	281	2.4
Salt Creek near Sussex, WY	0.00	44.4	0
Crazy Woman Creek at Upper Station near Arvada, WY	0.51	56.7	0.9
Clear Creek nr Arvada, WY	1.26	181	0.7
Middle Powder River at Broadus, MT	0.38	465	0.08
Little Powder River above Dry C near Weston, WY	0.43	22.9	1.9
Antelope Creek near Teckla, WY	0.74	12.6	5.9
Upper Cheyenne River near Riverview	0.22	60	0.4
Upper Belle Fourche River below Moorcroft, WY	3.18	24.6	13
Alternative 2B			
Upper Tongue River at State Line near Decker, WY	2.97	463	0.6
Upper Powder River at Arvada, WY	9.13	281	3.2
Salt Creek near Sussex, WY	0.00	44.4	0
Crazy Woman Creek at Upper Station near Arvada, WY	1.23	56.7	2.2
Clear Creek nr Arvada, WY	3.02	181	1.7
Middle Powder River at Broadus, MT	0.54	465	0.1
Little Powder River above Dry C near Weston, WY	0.61	22.9	2.7
Antelope Creek near Teckla, WY	0.74	12.6	5.9
Upper Cheyenne River near Riverview	0.22	60	0.4
Upper Belle Fourche River below Moorcroft, WY	3.53	24.6	14
Alternative 3			
Upper Tongue River at State Line near Decker, WY	1.52	463	0.3
Upper Powder River at Arvada, WY	6.71	281	2.4
Salt Creek near Sussex, WY	0.01	44.4	0.02
Crazy Woman Creek at Upper Station near Arvada, WY	1.57	56.7	2.8
Clear Creek nr Arvada, WY	2.12	181	1.2
Middle Powder River at Broadus, MT	0.17	465	0.04
Little Powder River above Dry C near Weston, WY	0.62	22.9	2.7
Antelope Creek near Teckla, WY	0.34	12.6	2.7
Upper Cheyenne River near Riverview	0.18	60	0.3
Upper Belle Fourche River below Moorcroft, WY	1.52	24.6	6.2

Notes:
[1] Extracted from Table 4–1.
[2] Extracted from Table 3-5.

The quality of the produced water is not expected to effect stock watering. Salinity values as high as 3,500 mg/L TDS are still considered suitable for consumption by livestock. Many CBM produced waters are likely to have elevated salinity and concentrations of sodium, which can affect the suitability of the produced water for irrigation purposes. Because of the potential adverse effects from CBM produced water discharges on the quality of surface waters used for irrigation,

mass balance calculations were performed to project the suitability of the CBM produced water for irrigation purposes, when commingled with existing surface flows in the receiving streams. Effects from CBM discharges on downstream irrigation use, prior to commingling with existing surface flows in the receiving streams, would be analyzed by WDEQ under the NPDES program.

Mass balance calculations of CBM surface discharge contributions to existing water quality and flow data were performed to provide an estimate of flow, salinity, and SAR expected in the year 2002 when the Project is implemented. Mass balance calculations were performed using flow-weighted averages. Available water quality data for currently producing CBM wells are summarized in Table 3–2. Projected future flows of CBM produced water are summarized in Tables 2–8 and 2–32. Existing surface water quality and flow data by sub-watershed are provided in Appendix E and Table 3–5, respectively. For the purposes of the analysis, the following assumptions were used. Mass balance calculations assume that the CBM produced water discharges reach the receiving streams at the sub-watershed boundary unchanged in water quality. Baseline water quality of the receiving streams is assumed to be the same during low flow conditions as during average flow conditions.

The results of the mass balance calculations were utilized to project the combined effect on the quality of the water for irrigation purposes. Effects were analyzed utilizing Figure 4–12, which provides guidelines for assessing potential effects on infiltration associated with SAR and salinity levels in irrigation waters (Hansen et al. 1999). The diagonal line indicating "No Reduction in Infiltration" illustrates the combination of SAR and salinity values that can be expected to reduce

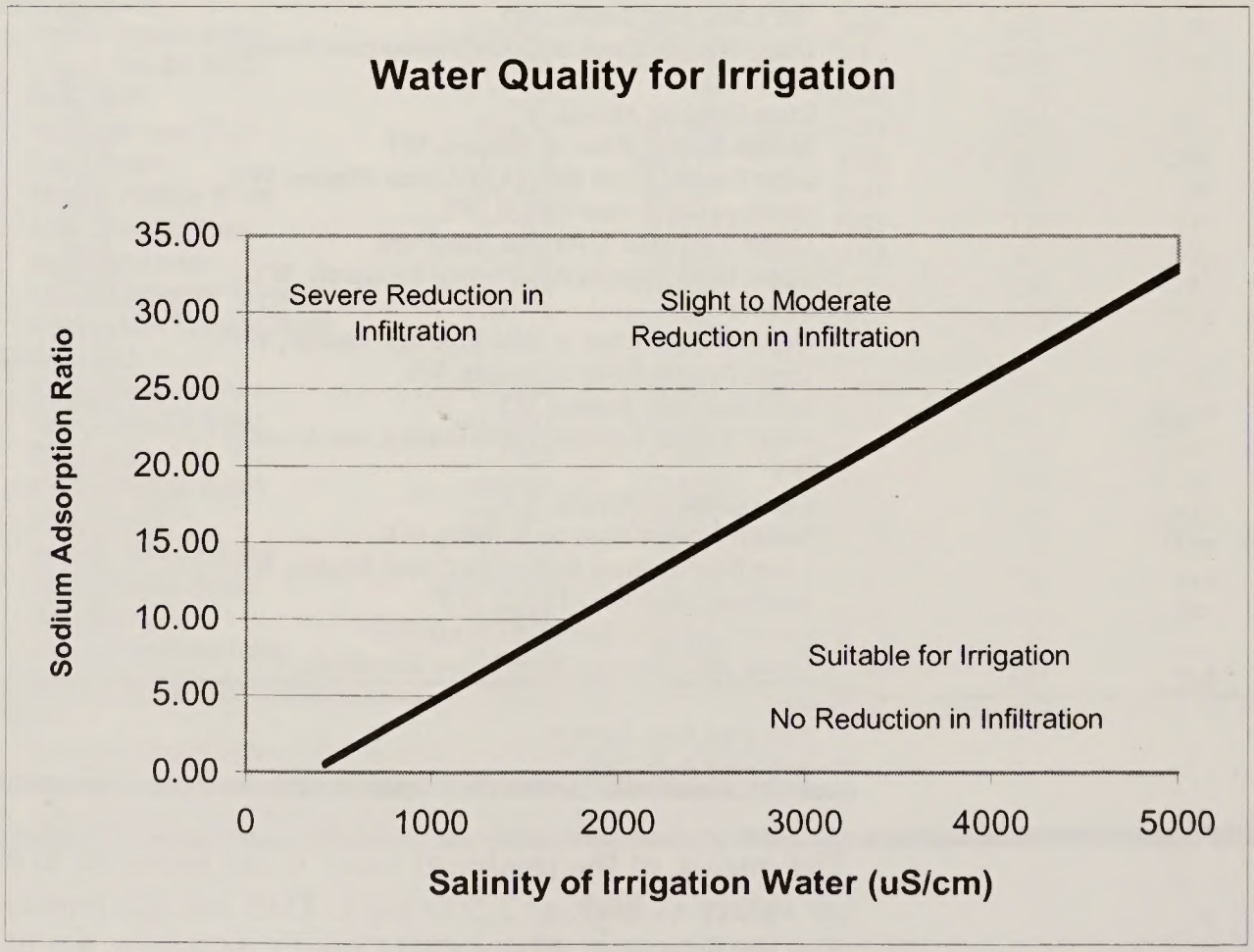


Figure 4–12 Effects of Salinity and SAR on Infiltration

the infiltration capacity of a wide variety of soils, and thus, effect the suitability of the water for irrigation. This line is referred to as the Hanson Line in the figures that follow. Salinity is expressed as specific conductance in microSiemans per centimeter (μS/cm).

Upper Tongue River Sub-Watershed

Effects on water quality in the Upper Tongue River are illustrated in Figure 4–13 and Figure 4–14. Limited information is currently available on CBM water production and quality in the Tongue River sub-watershed. For the purpose of this analysis, CBM water quality was based on samples from CBM wells located in Montana, just outside the Project Area. The representative water quality has a salinity of 2,099 μS/cm and an SAR of 52 (AHA 2000).

The additional flow attributable to produced water (3.4 cfs) would result in very minor contributions to the flow of the Tongue River. Salinity values would increase slightly above existing conditions, from 513 to 532 μS/cm. SAR values would increase from 0.5 to 1.1. The estimated increases in salinity and SAR from CBM discharges in the Tongue River sub-watershed would not alter the irrigation suitability of the Upper Tongue River.

Under Alternative 1, CBM discharges in the Upper Tongue River sub-watershed would undergo treatment prior to discharge. Water quality effects would be minimized, depending on the level and method of treatment.

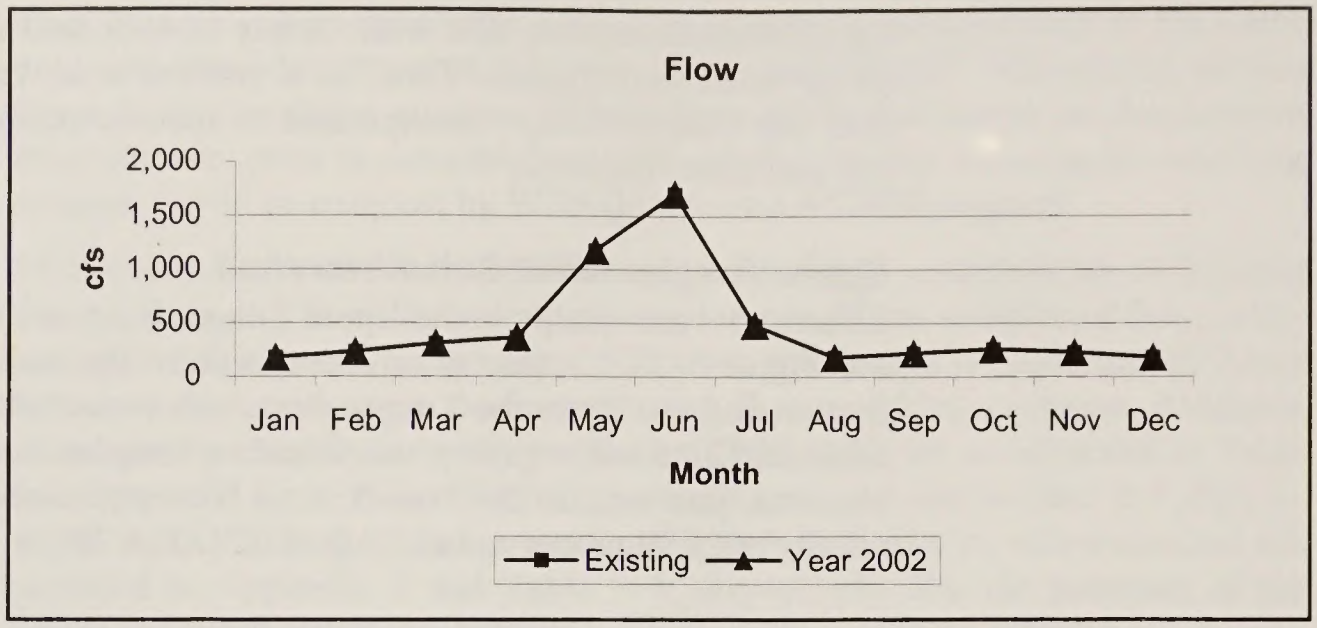
Upper Powder River Sub-Watershed

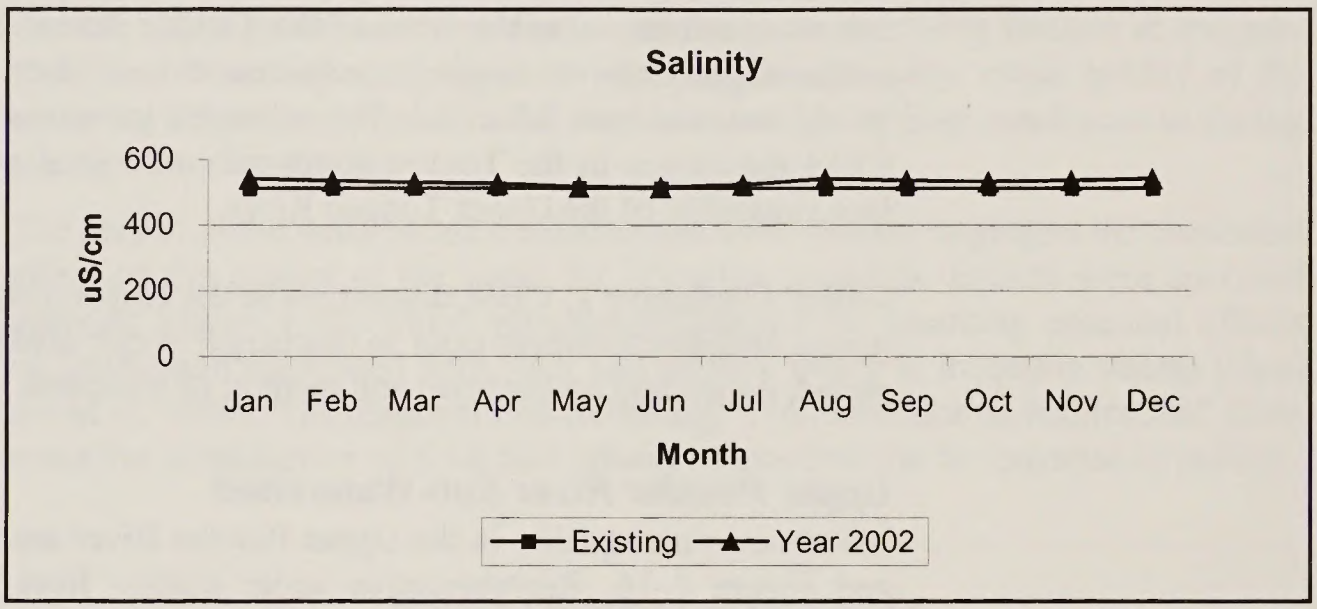
Effects on water quality in the Upper Powder River are illustrated in Figure 4–15 and Figure 4–16. Representative water quality from CBM wells in the sub-watershed has an average salinity of 2,428 μS/cm and an average SAR of 13.5 (Energy Labs 2001).

Flows expected from CBM produced water discharges (22.2 cfs) would result in slight contributions to the flow of the Upper Powder River. Salinity values would increase slightly above existing conditions, from 2,057 to 2,101 μS/cm. SAR values would increase from 4.8 to 5.8. The water in the Upper Powder River would be expected to remain suitable for irrigation purposes.

Salt Creek Sub-Watershed

Currently there is no CBM development in the Salt Creek sub-watershed, so mass balance calculations could not be performed. Existing water quality in Salt Creek is high in salinity (5,797 μS/cm) and SAR (15.5). With CBM flows of 0.02 cfs projected for the sub-watershed, the combined water quality would likely remain unchanged. The water in Salt Creek is of poor quality for livestock consumption due to the high salinity.





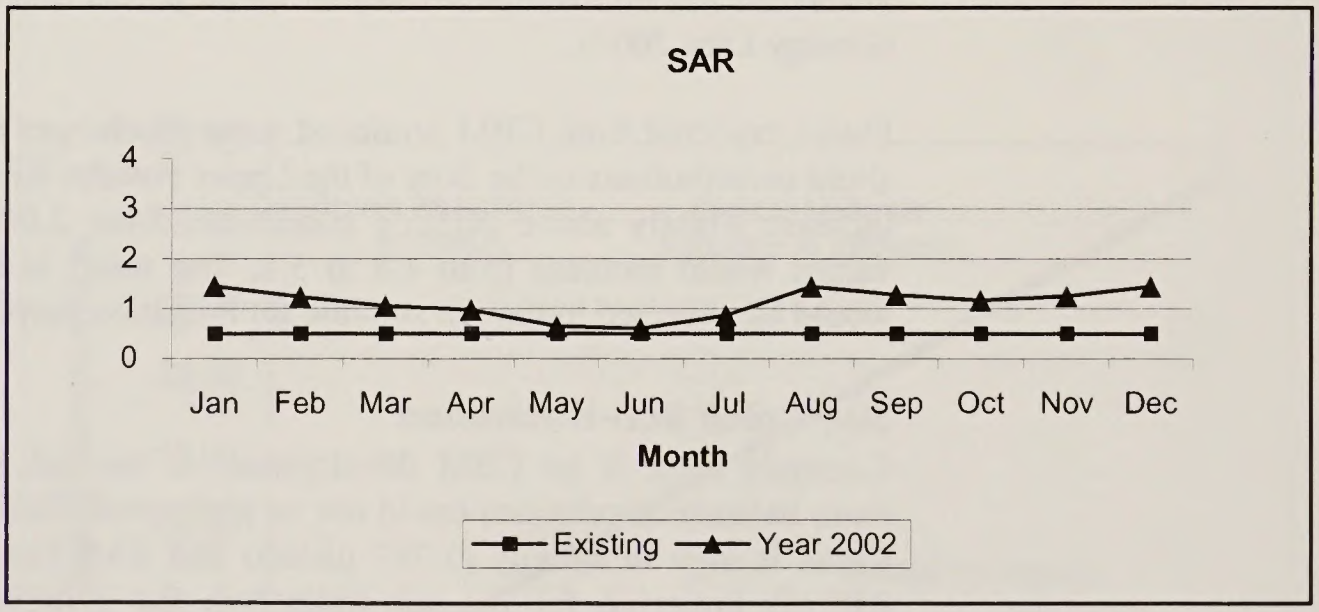


Figure 4–13 Existing and Projected Water Quality in Year 2002 — Upper Tongue River Sub-Watershed

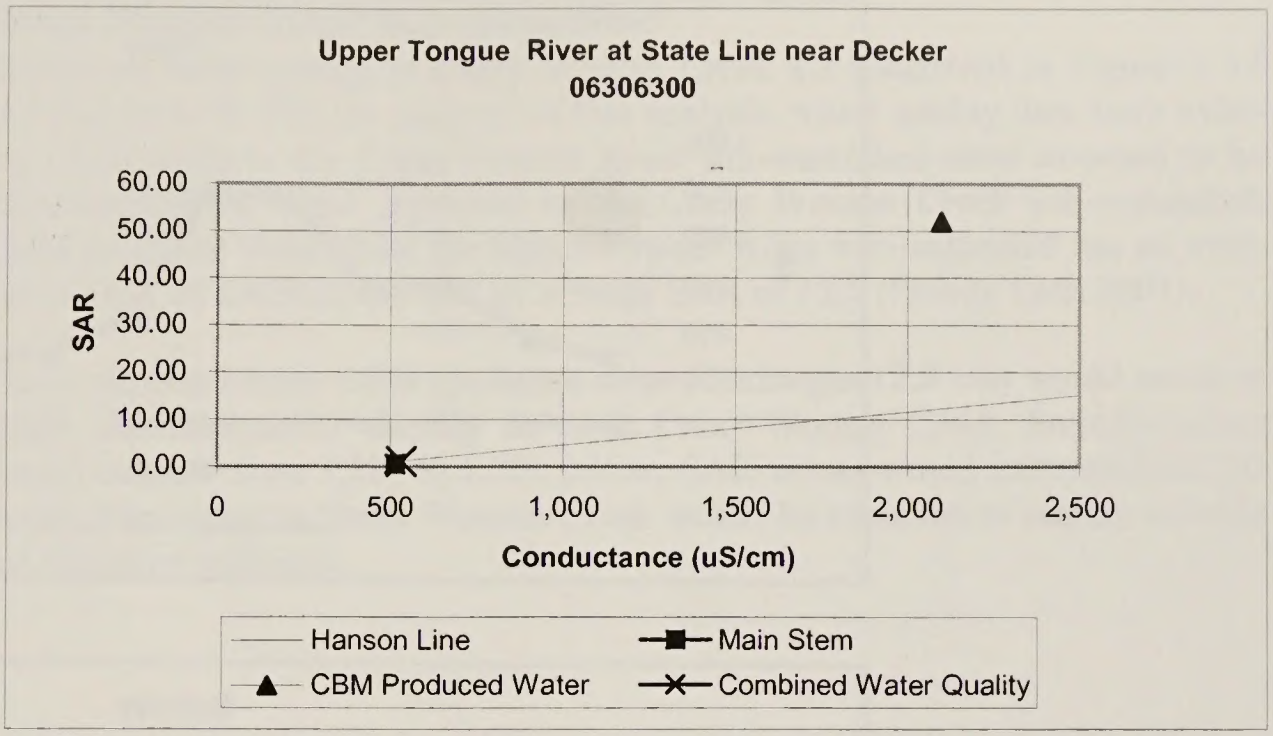


Figure 4–14 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Upper Tongue River Sub-Watershed

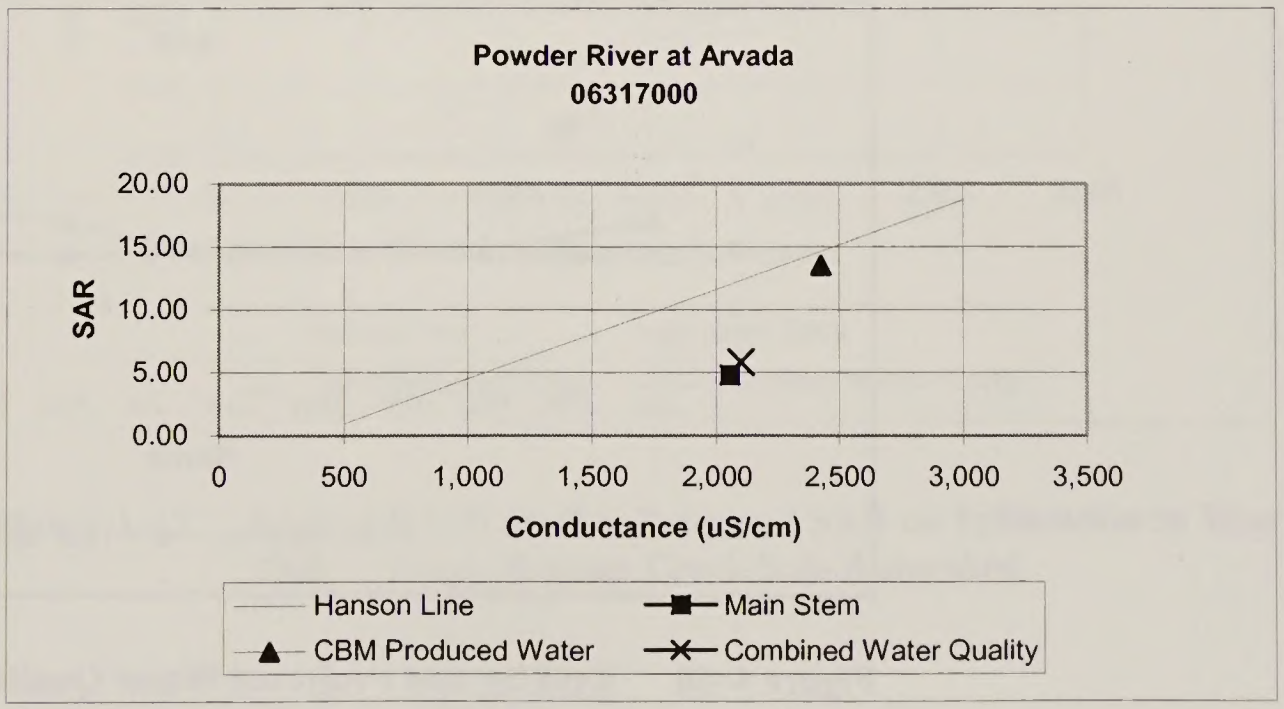
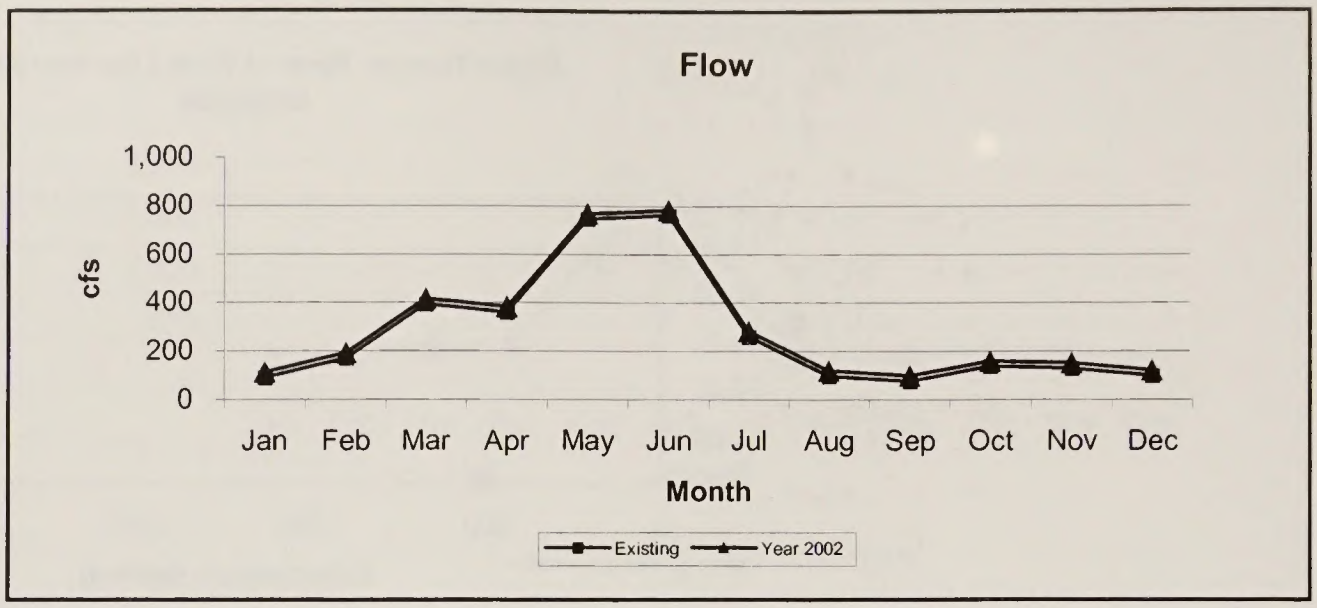
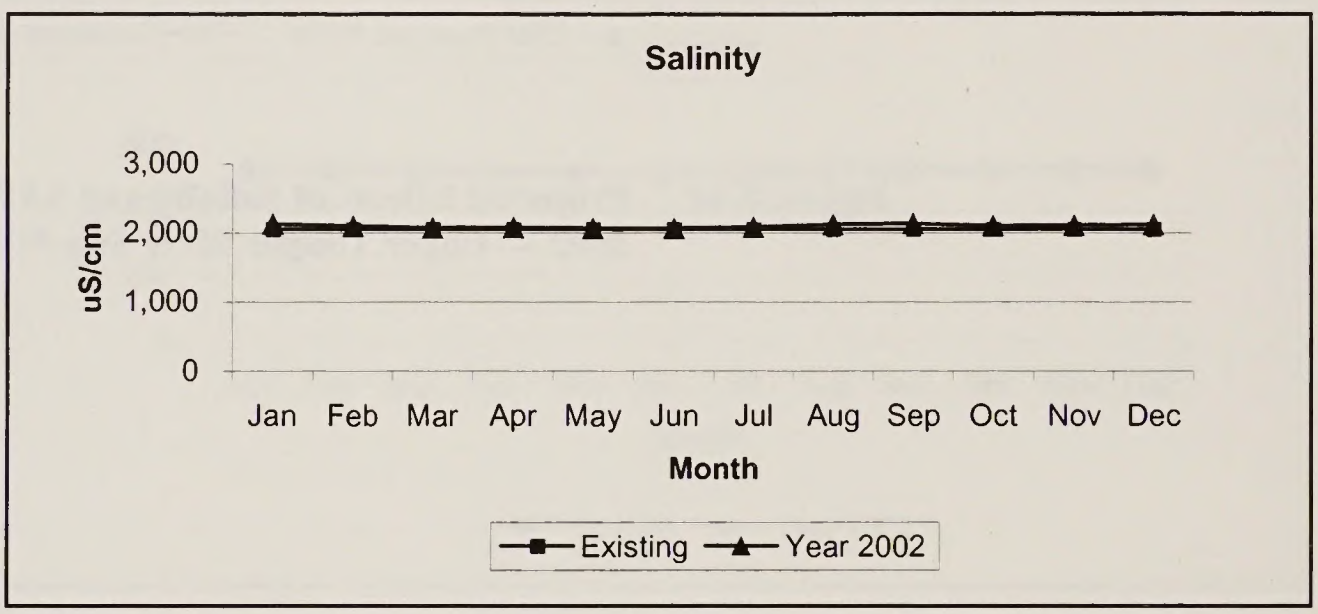


Figure 4–15 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Upper Powder River Sub-Watershed





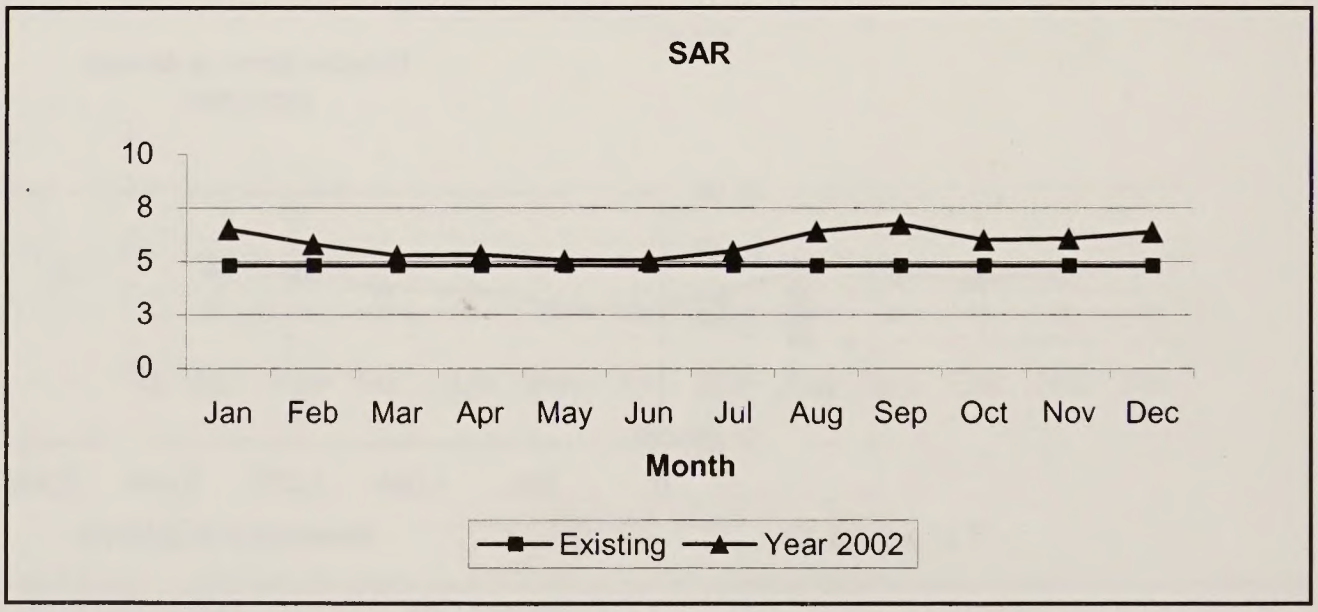


Figure 4–16 Existing and Projected Water Quality in Year 2002 — Upper Powder River Sub-Watershed

Crazy Woman Creek Sub-Watershed

Effects on water quality in Crazy Woman Creek are illustrated in Figure 4–17 and Figure 4–18. For the purpose of this analysis, water quality data from existing CBM wells in the Upper Powder River sub-watershed were assumed to be representative of water produced in the Crazy Woman Creek sub-watershed. CBM produced water from the Upper Powder River sub-watershed has an average salinity of 2,428 µS/cm and an average SAR of 13.5 (Energy Labs 2001).

Flows expected from CBM produced water discharges (2.8 cfs) would result in slight contributions to existing flows in Crazy Woman Creek. Salinity values would increase from 1,185 to 1,306 µS/cm. SAR values would increase from 2.0 to 3.1. The water in Crazy Woman Creek would be expected to remain suitable for irrigation purposes.

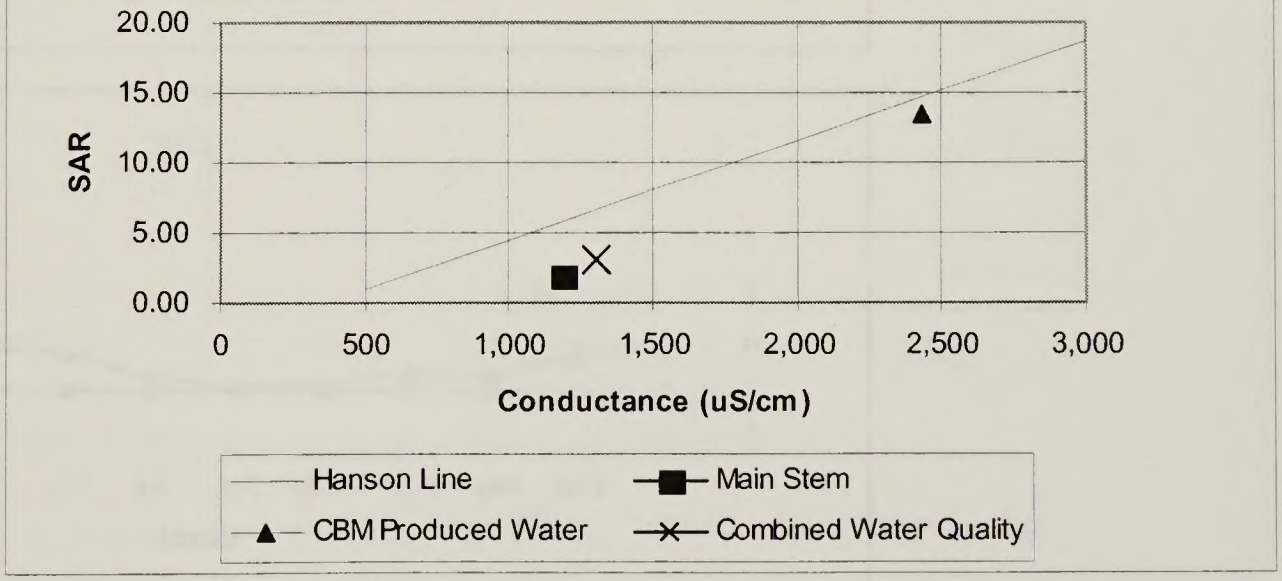
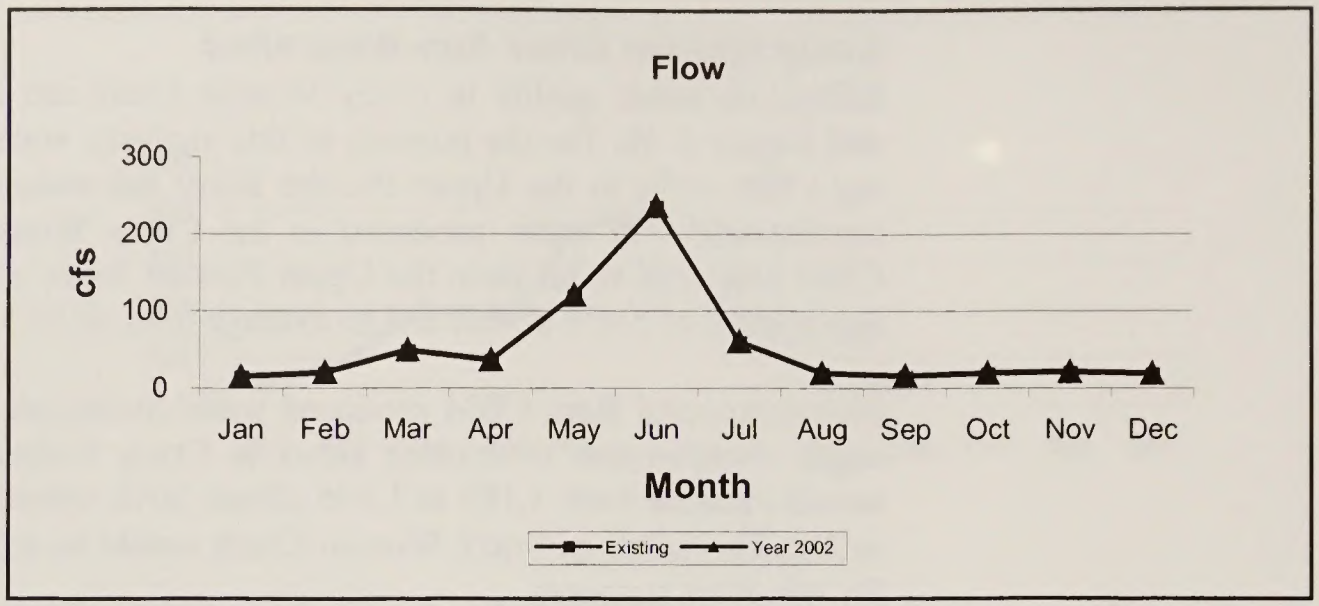
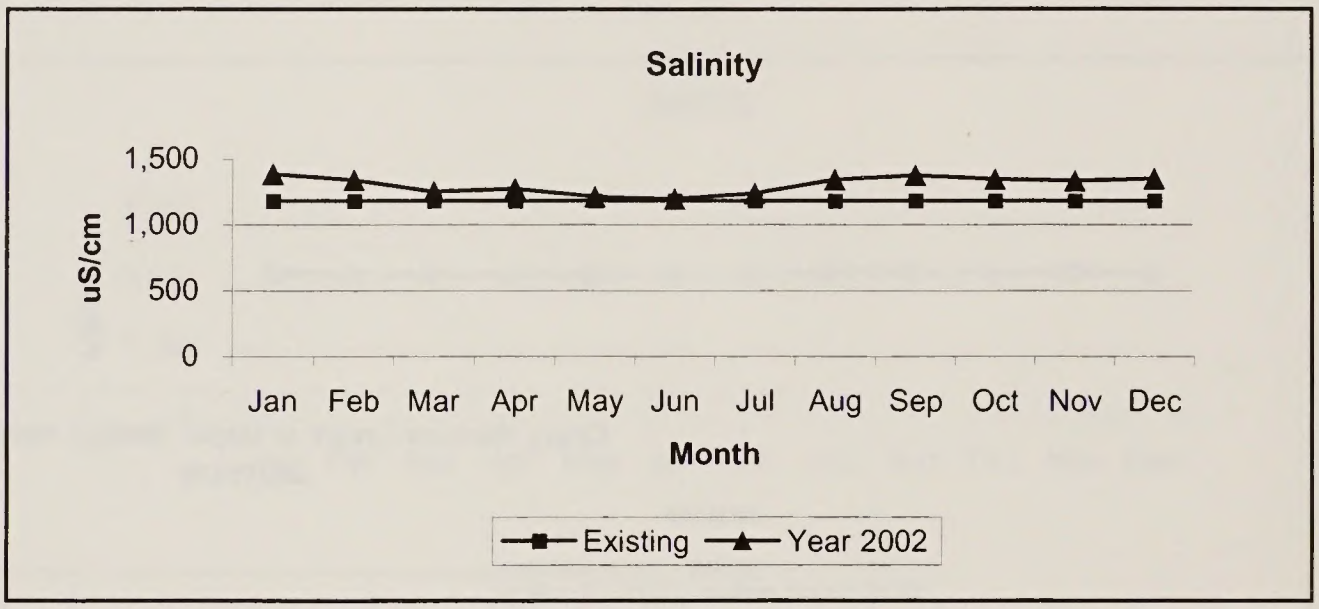


Figure 4–17 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Crazy Woman Creek Sub-Watershed





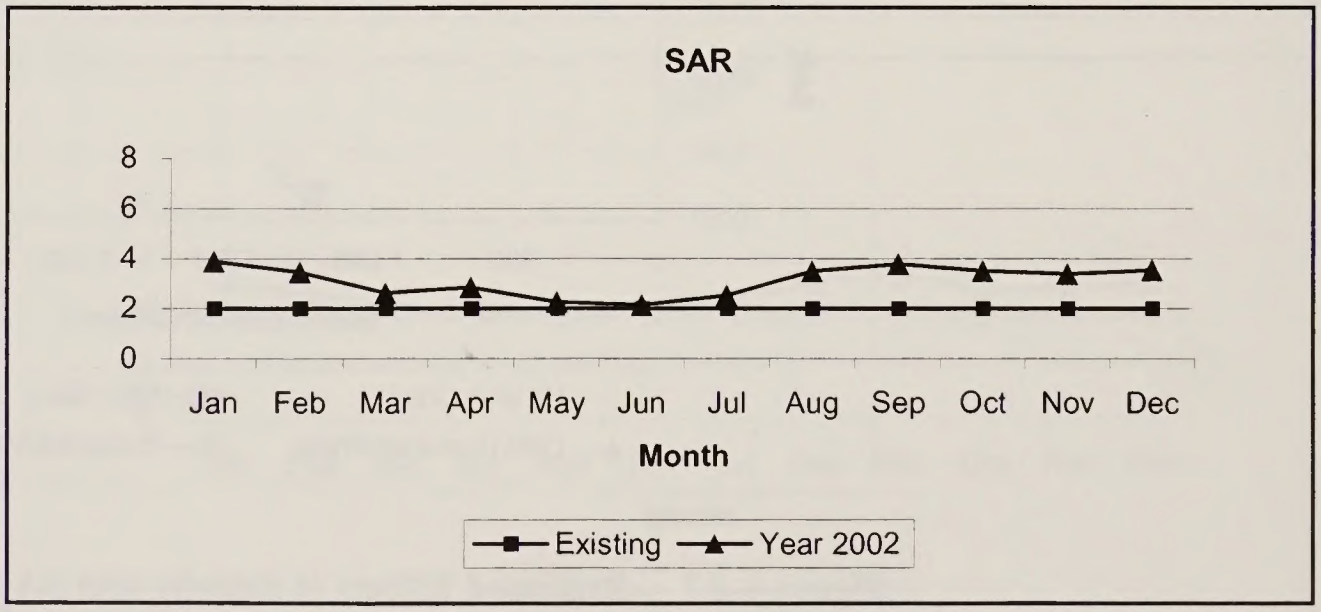


Figure 4–18 Existing and Projected Water Quality in Year 2002 — Crazy Woman Creek Sub-Watershed

Clear Creek Sub-Watershed

Effects on water quality in Clear Creek are illustrated in Figure 4–19 and Figure 4–20. For the purpose of this analysis, water quality data from existing CBM wells in the Upper Powder River sub-watershed were assumed to be representative of water produced in the Clear Creek sub-watershed. CBM produced water from the Upper Powder River sub-watershed has an average salinity of 2,428 µS/cm and an average SAR of 13.5 (Energy Labs 2001).

The additional flow attributable to produced water (2.4 cfs) would result in very minor contributions to the flow of Clear Creek. Salinity values would increase slightly above existing conditions, from 1,141 to 1,167 µS/cm. SAR values would increase from 1.1 to 1.4. The slight increases in salinity and SAR from CBM discharges in the Clear Creek sub-watershed would not alter the irrigation suitability of Clear Creek. The combined water quality would be expected to be suitable for irrigation.

Under Alternative 1, about one-third of the CBM discharges in this watershed would be treated prior to discharge. Effects on water quality in Clear Creek would be minimized, depending on the level and method of treatment.

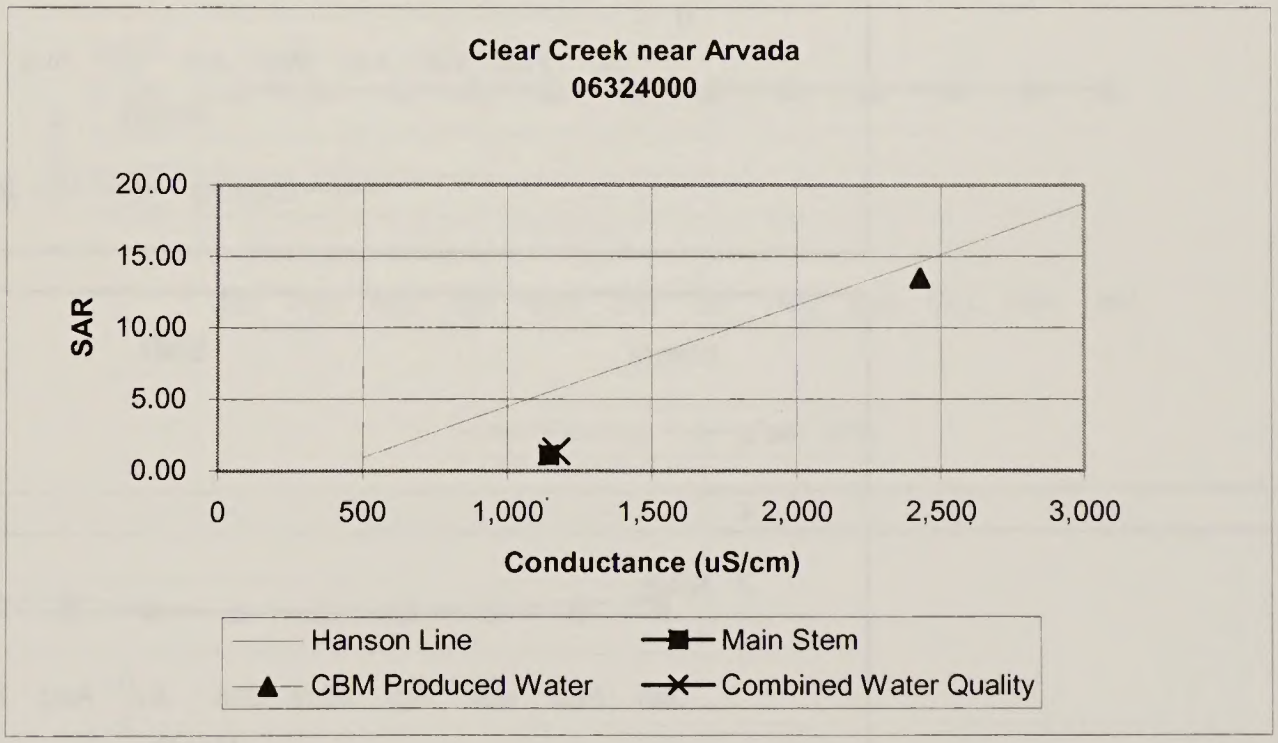
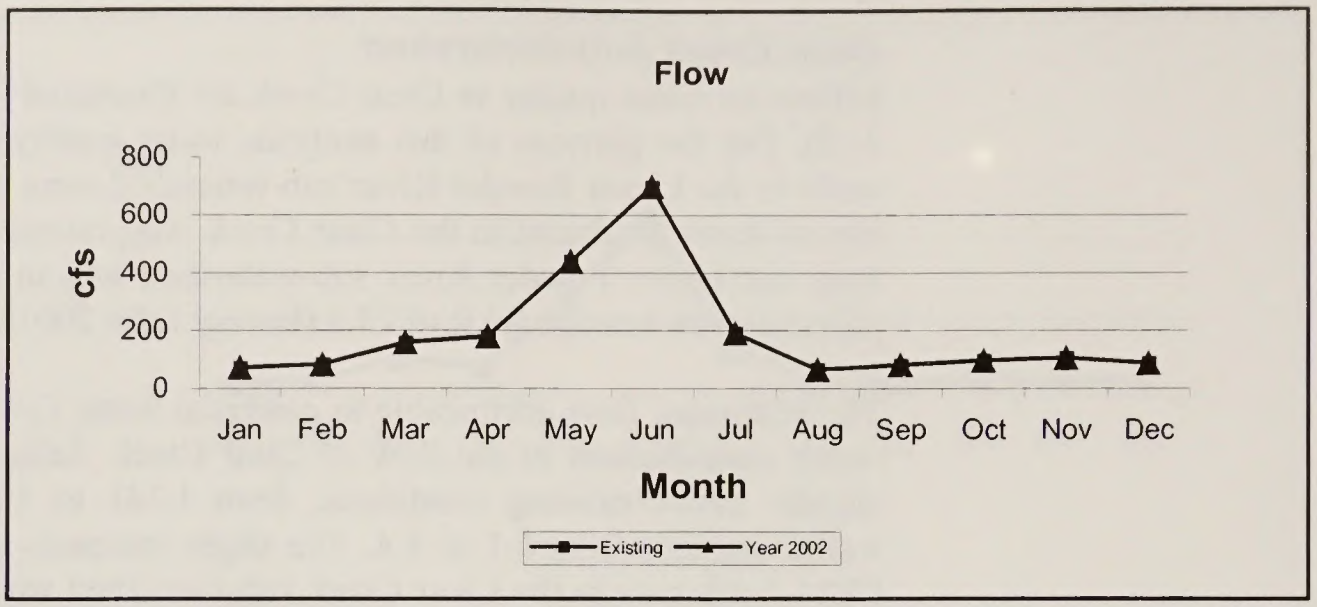
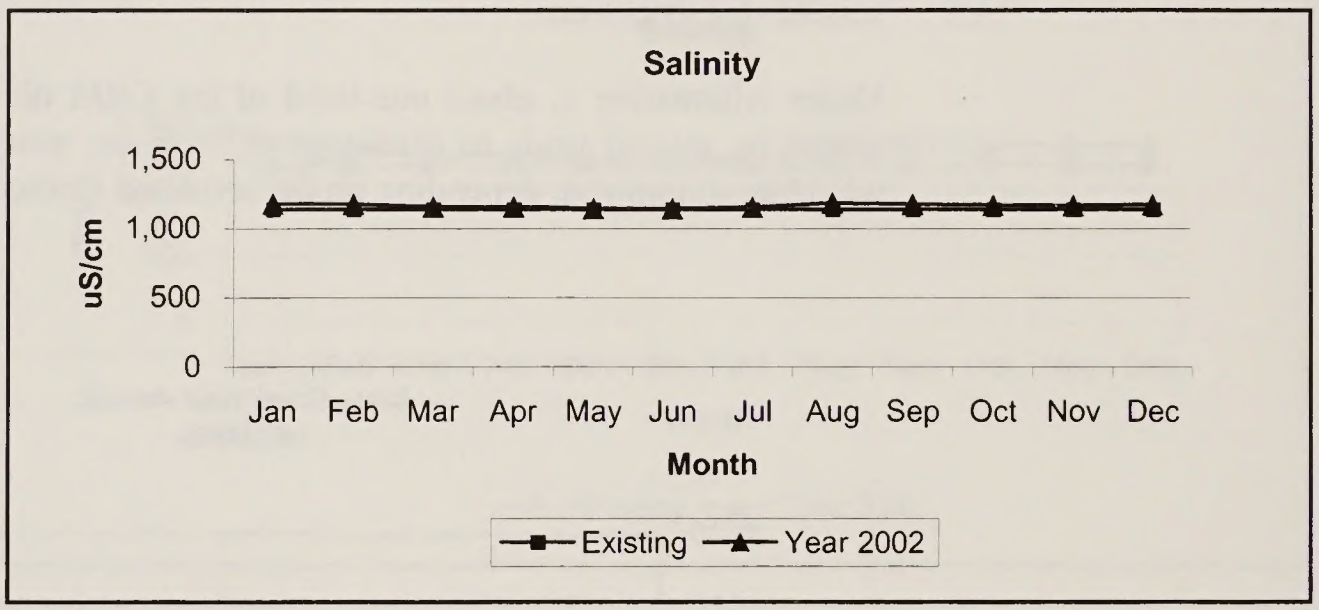


Figure 4–19 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Clear Creek Sub-Watershed





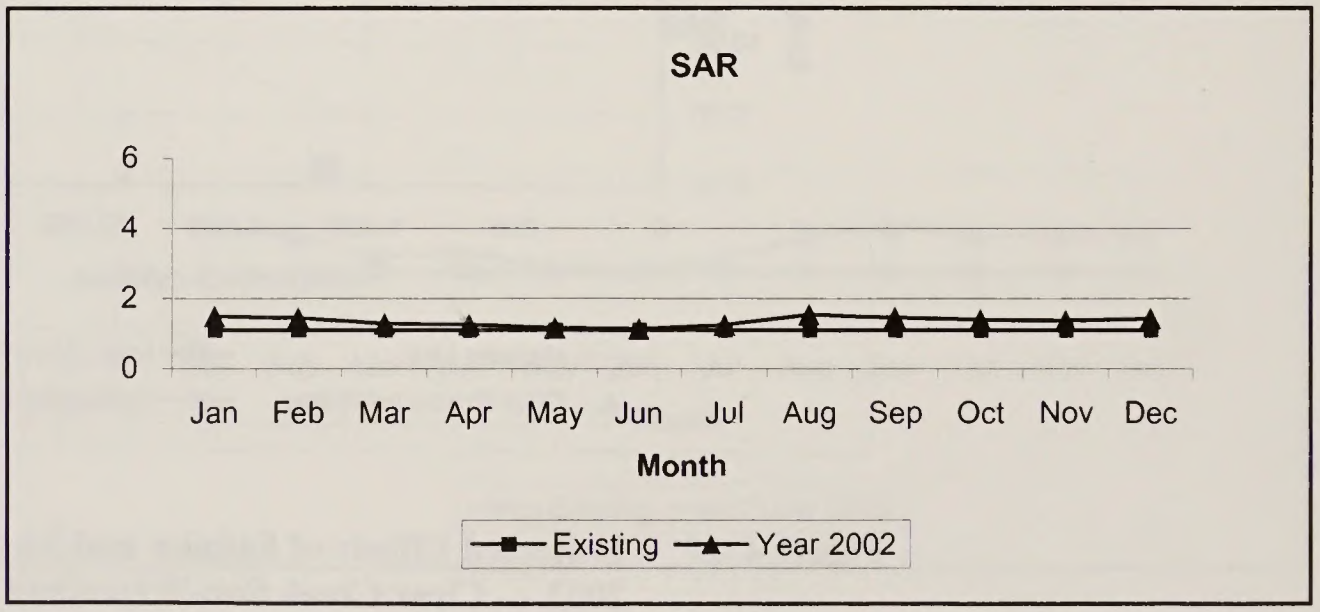
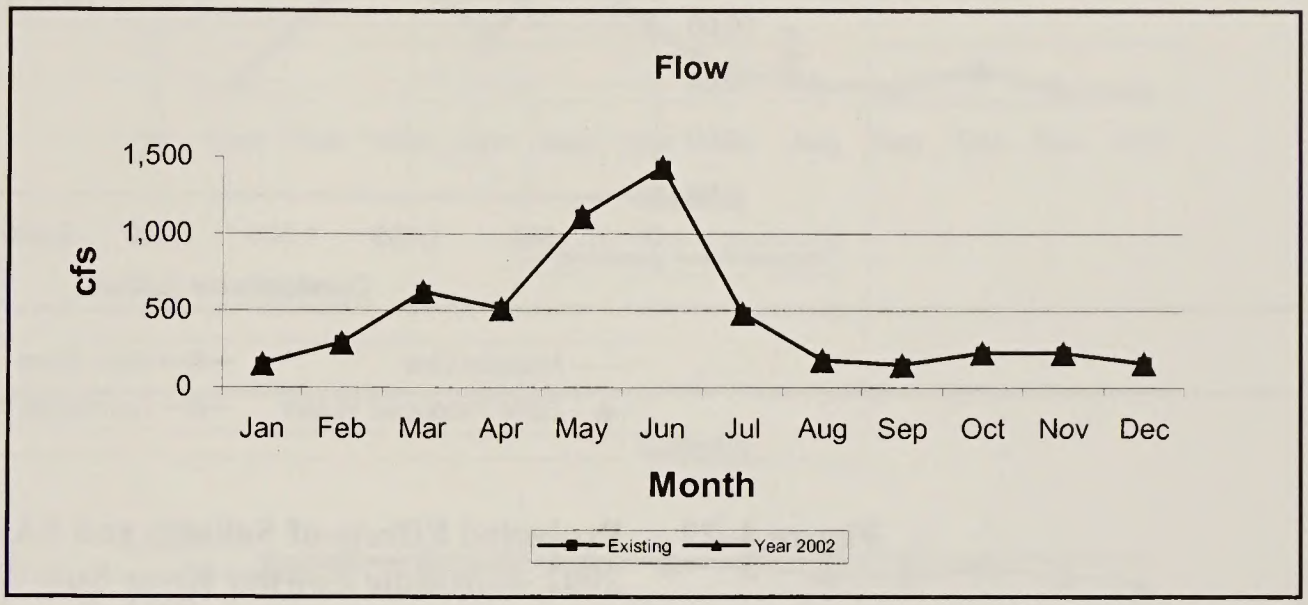
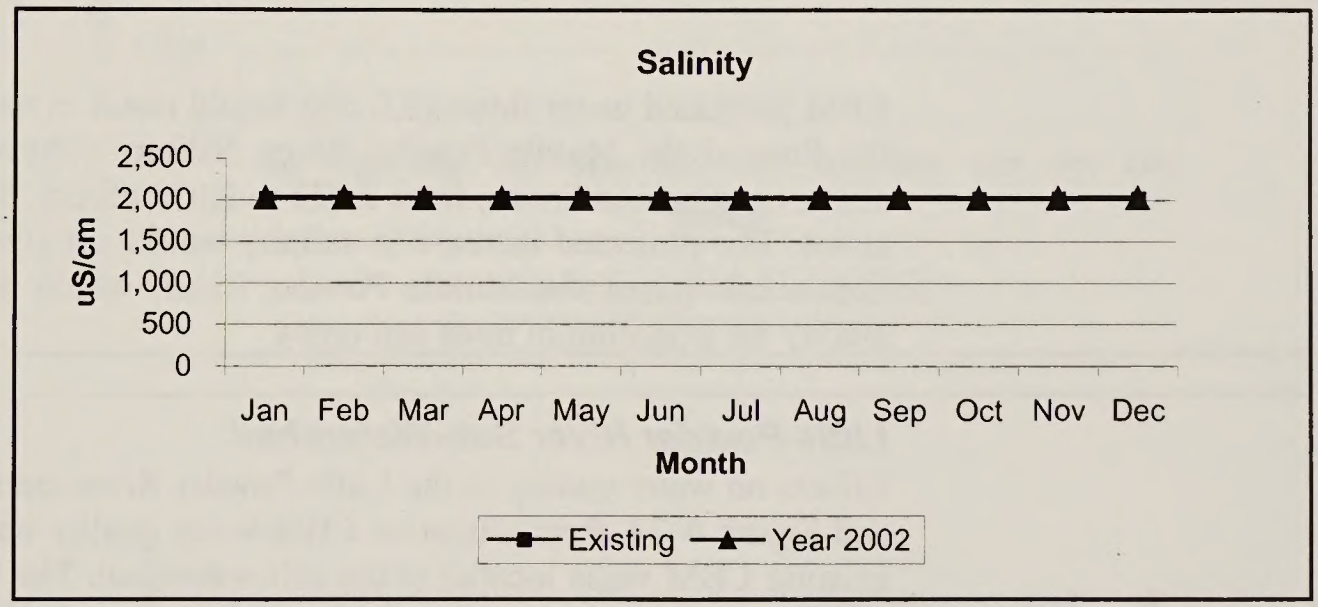


Figure 4–20 Existing and Projected Water Quality in Year 2002 — Clear Creek Sub-Watershed

Middle Powder River Sub-Watershed

Effects on water quality in the Middle Powder River are illustrated in Figure 4–21 and Figure 4–22. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality has a salinity of 3,423 µS/cm and an SAR of 3.7 (Energy Laboratories 2001).





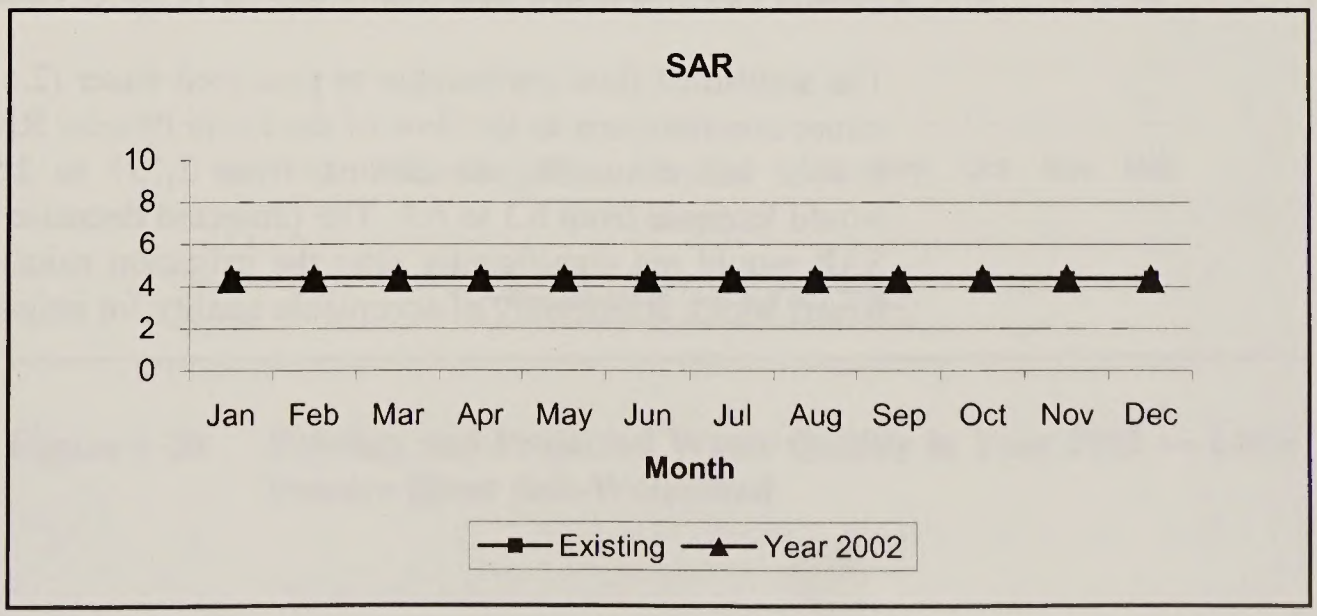


Figure 4–21 Existing and Projected Water Quality in Year 2002 — Middle Powder River Sub-Watershed

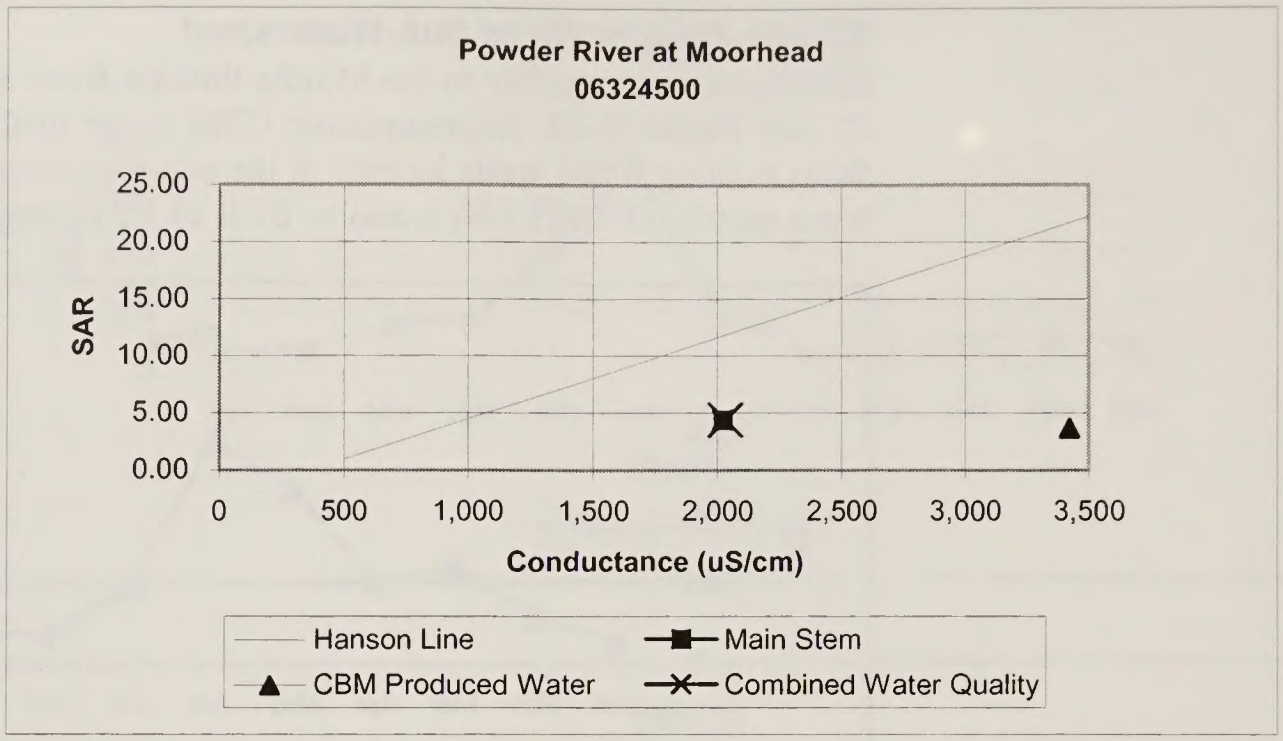


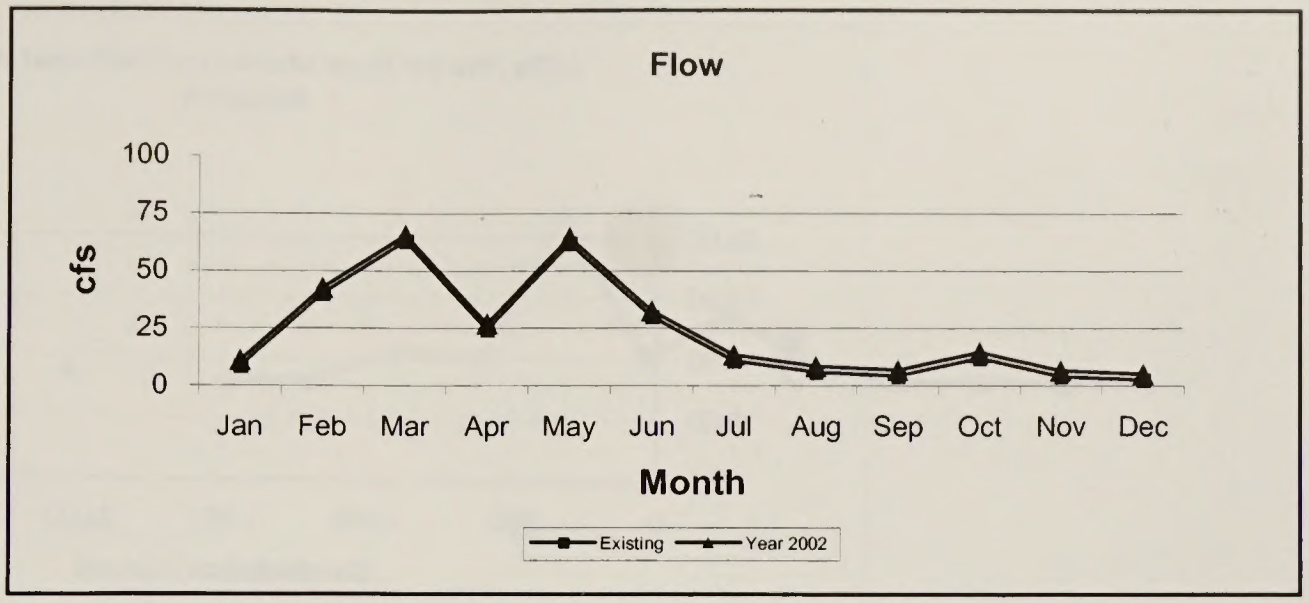
Figure 4–22 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Middle Powder River Sub-Watershed

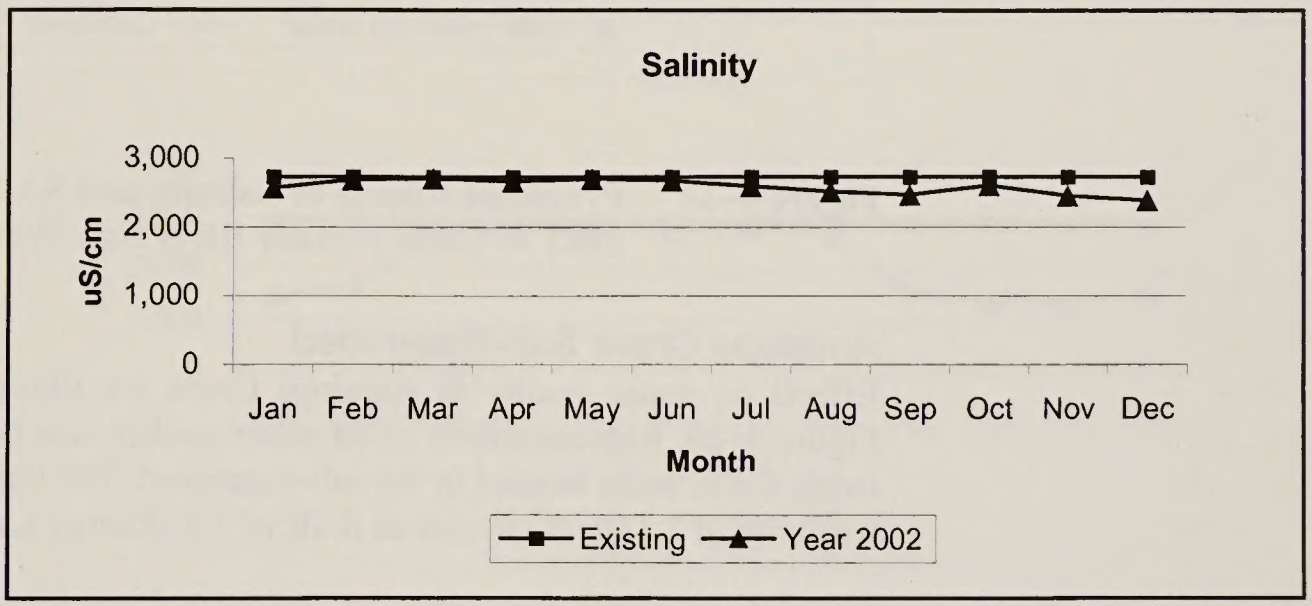
CBM produced water flows (2.0 cfs) would result in very minor contributions to the flow of the Middle Powder River. Salinity values would increase slightly above existing conditions, from 2,023 to 2,033 µS/cm. SAR values would remain at 4.4. The projected increase in salinity would not significantly alter the irrigation suitability of the Middle Powder River, which is currently of acceptable quality for irrigation of most soil types.

Little Powder River Sub-Watershed

Effects on water quality in the Little Powder River are illustrated in Figure 4–23 and Figure 4–24. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality has a salinity of 2,048 µS/cm and an SAR of 8.9 (Energy Laboratories 2001).

The additional flow attributable to produced water (2.6 cfs) would result in very minor contributions to the flow of the Little Powder River. Salinity values would decline below existing conditions, from 2,737 to 2,593 µS/cm. SAR values would increase from 6.1 to 6.8. The projected decrease in salinity and increase in SAR would not significantly alter the irrigation suitability of the Little Powder River, which is currently of acceptable quality for irrigation of most soil types.





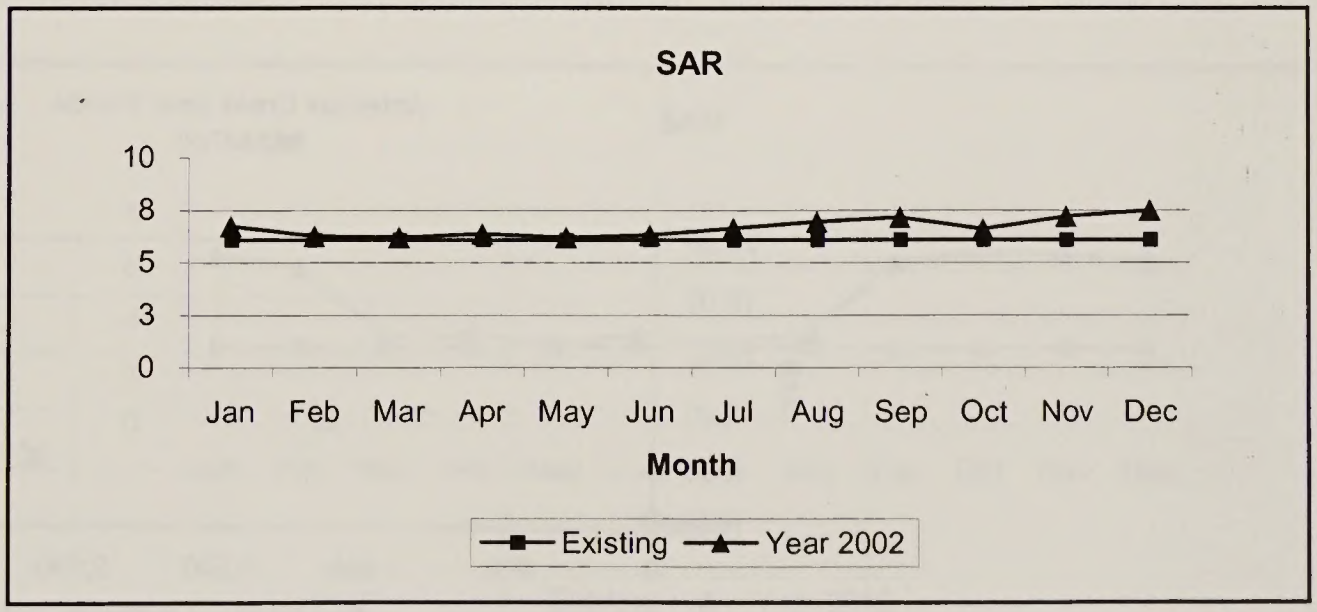


Figure 4–23 Existing and Projected Water Quality in Year 2002 — Little Powder River Sub-Watershed

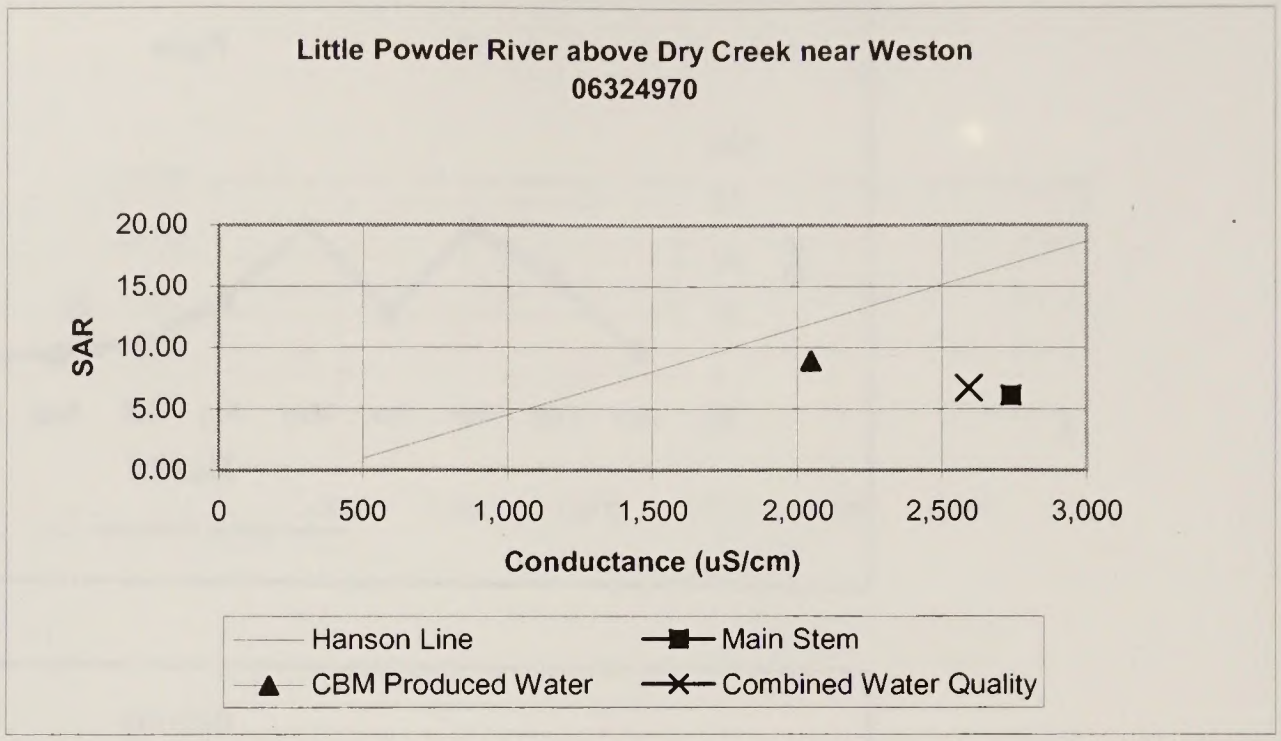


Figure 4–24 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Little Powder River Sub-Watershed

Antelope Creek Sub-Watershed

Effects on water quality in Antelope Creek are illustrated in Figure 4–25 and Figure 4–26. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality from has a salinity of 1,130 µS/cm and an SAR of 7.3 (Energy Laboratories 2001).

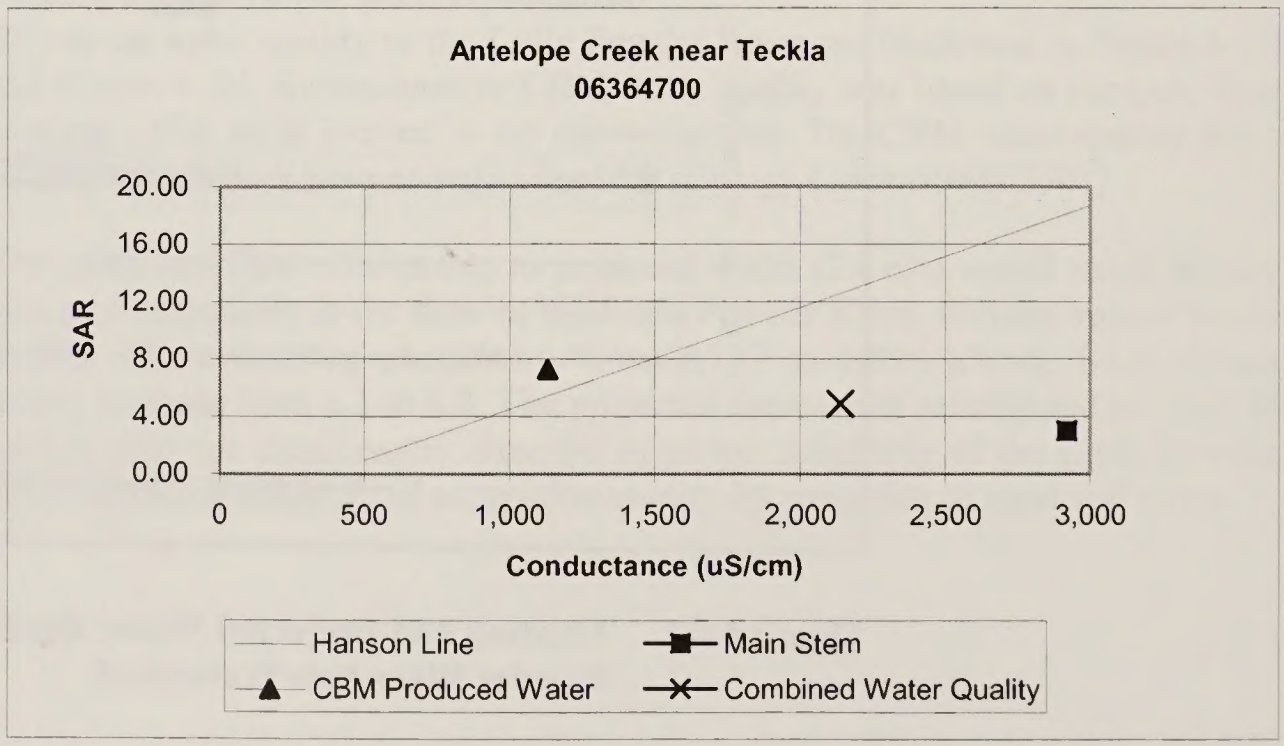
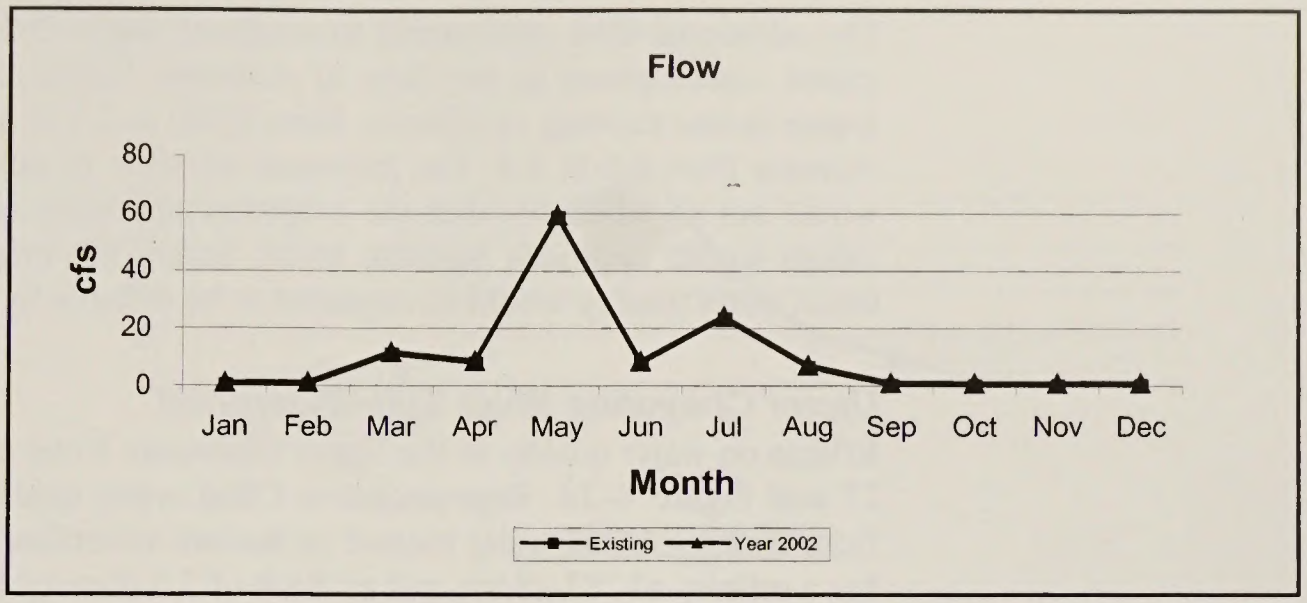
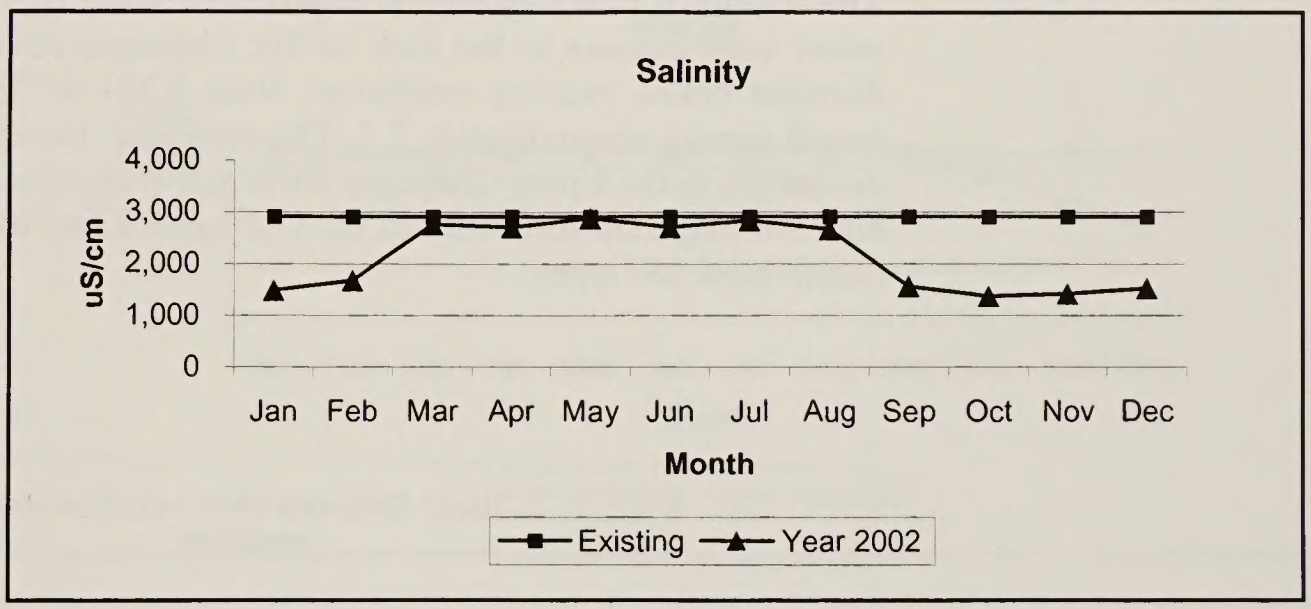


Figure 4–25 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Antelope Creek Sub-Watershed





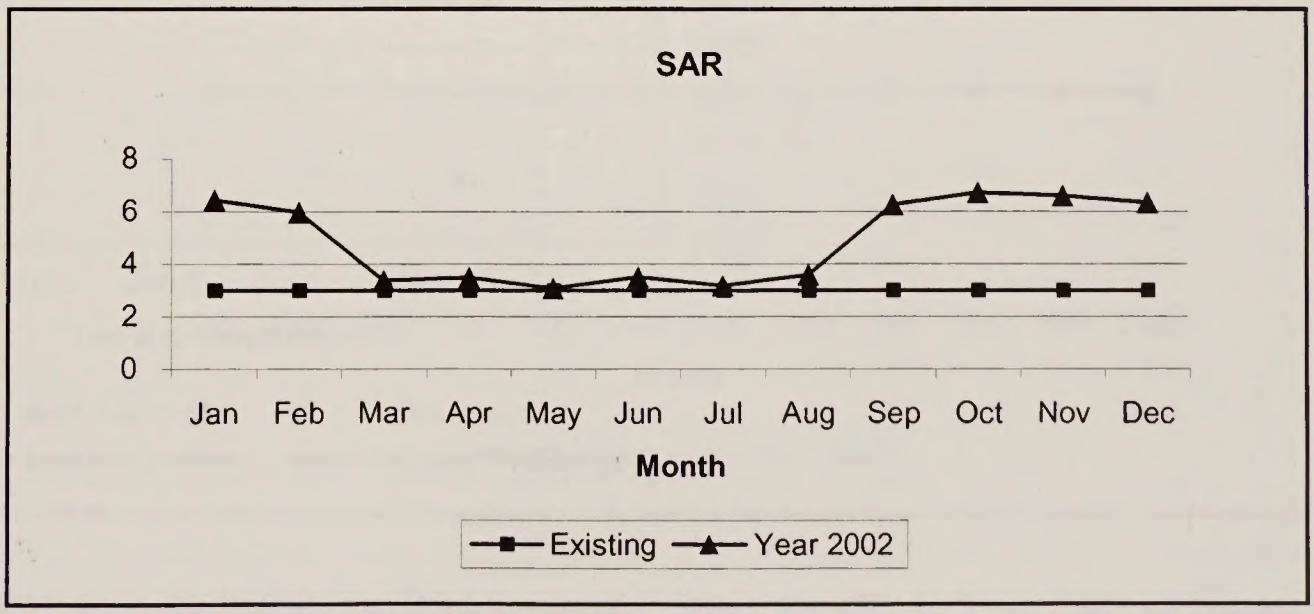


Figure 4–26 Existing and Projected Water Quality in Year 2002 — Antelope Creek Sub-Watershed

The additional flow attributable to produced water (0.9 cfs) would result in very minor contributions to the flow of Antelope Creek. Salinity values would decrease below existing conditions, from 2,920 to 2,138 µS/cm. SAR values would increase from 3.0 to 4.9. The projected decrease in salinity and increase in SAR would not significantly alter the irrigation suitability of Antelope Creek as both values would approach baseline levels during the irrigation months. The combined water quality would be expected to be suitable for irrigation.

Upper Cheyenne River Sub-Watershed

Effects on water quality in the Upper Cheyenne River are illustrated in Figure 4–27 and Figure 4–28. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality has a salinity of 787 µS/cm and an SAR of 7.0 (Energy Laboratories 2001).

The additional flow attributable to produced water (0.6 cfs) would result in very minor contributions to the flow of the Cheyenne River. Salinity values would decrease below existing conditions, from 3,321 to 3,025 µS/cm. SAR values would remain approximately 7.3. The projected decrease in salinity from CBM discharges in the Upper Cheyenne River sub-watershed would not be expected to alter the irrigation suitability of the Cheyenne River which is suitable for irrigation of most soil types.

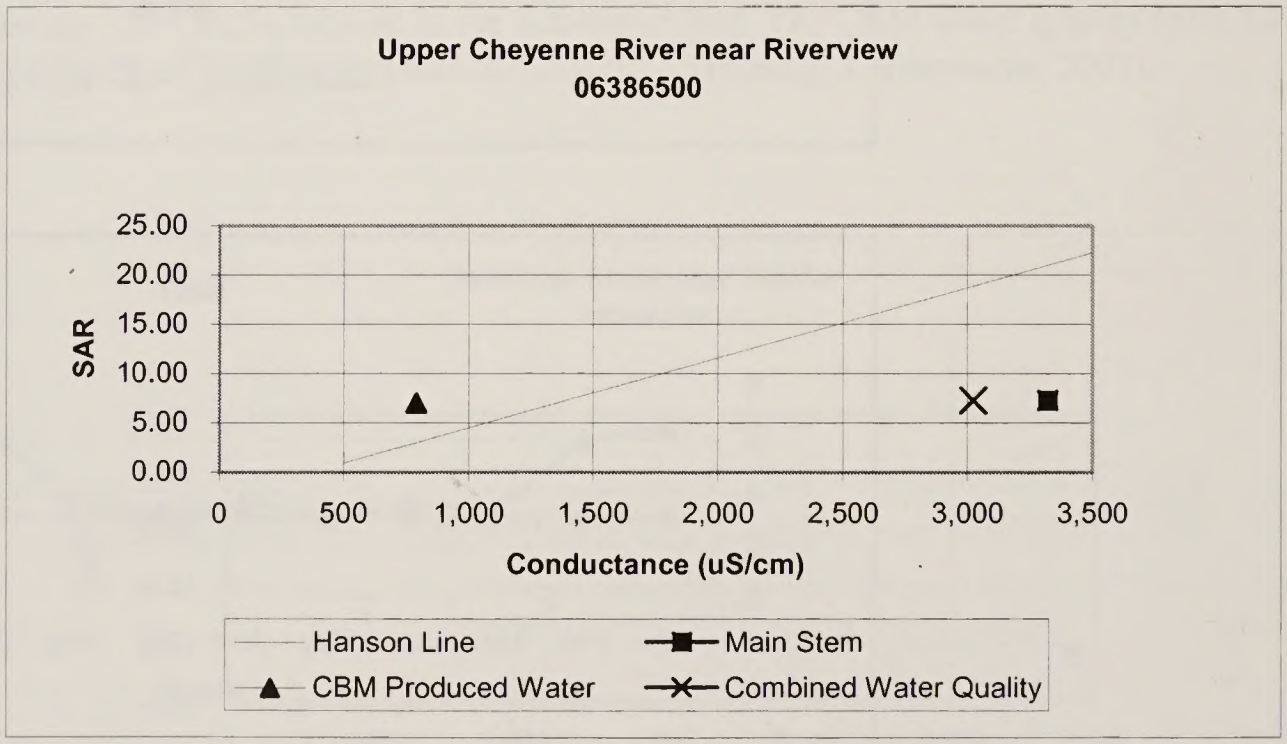
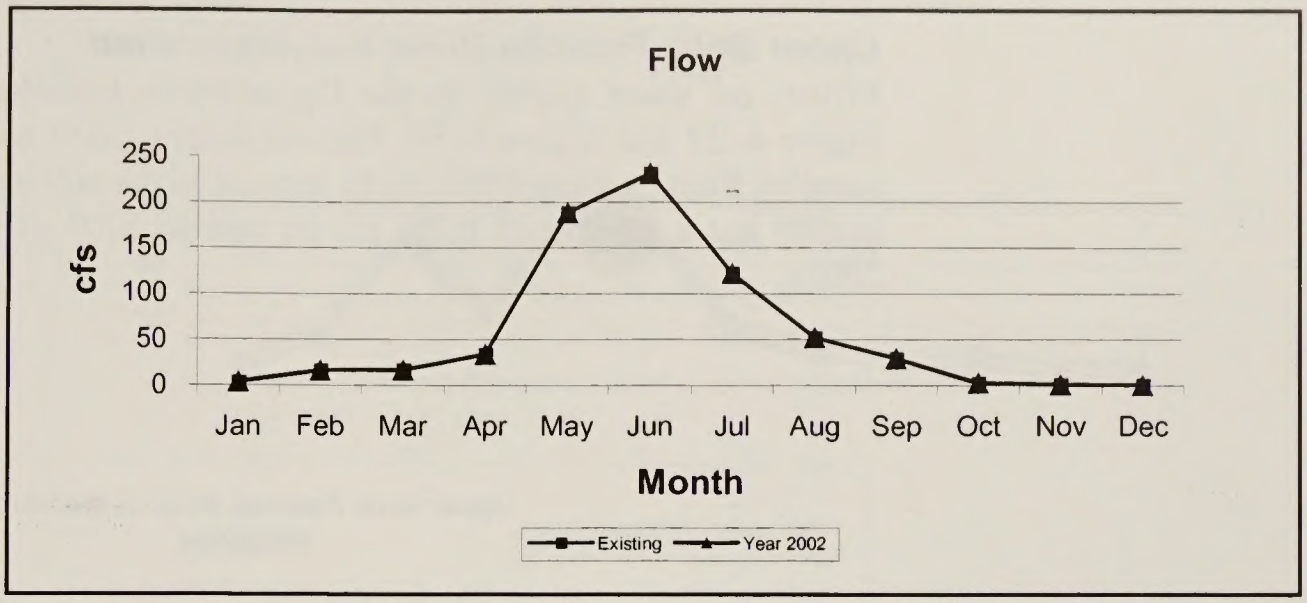
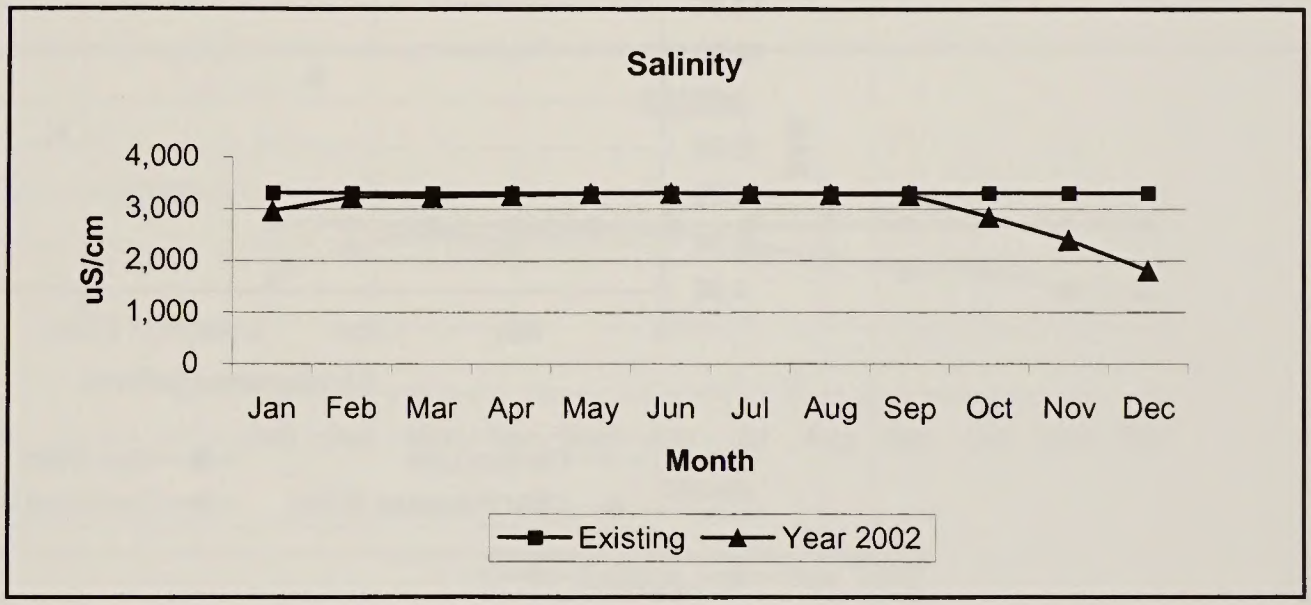


Figure 4–27 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Upper Cheyenne River Sub-Watershed





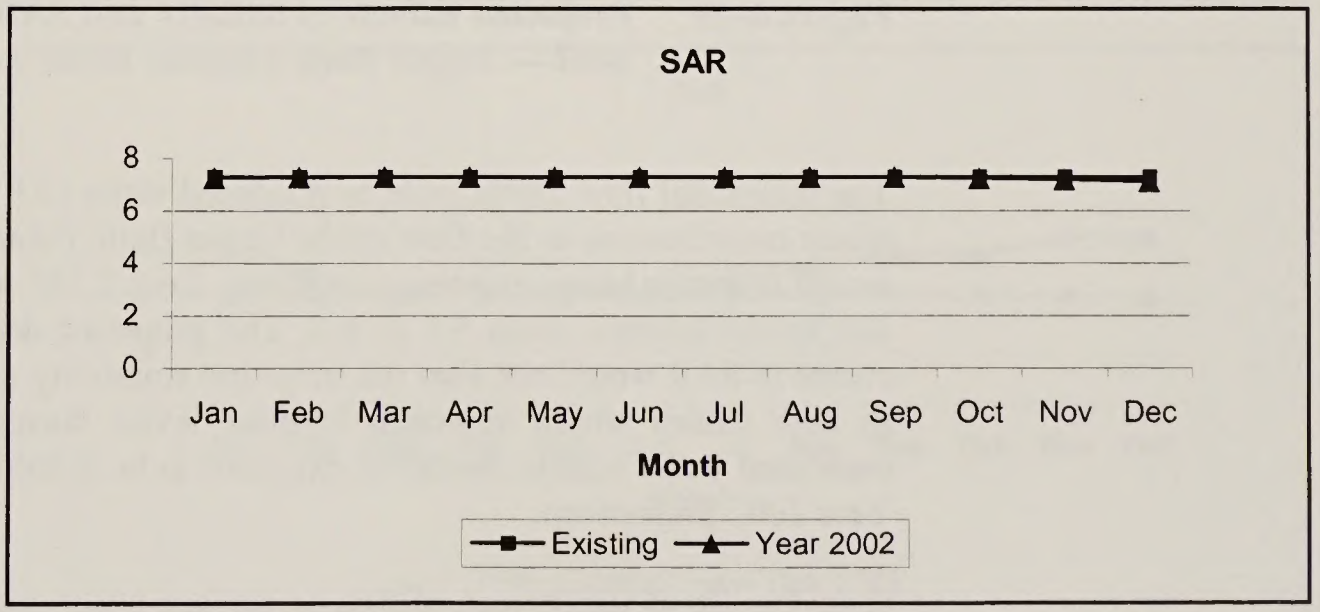


Figure 4–28 Existing and Projected Water Quality in Year 2002 — Upper Cheyenne River Sub-Watershed

Upper Belle Fourche River Sub-Watershed

Effects on water quality in the Upper Belle Fourche River are illustrated in Figure 4–29 and Figure 4–30. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality has a salinity of 1,202 µS/cm and an SAR of 9.1 (Energy Laboratories 2001).

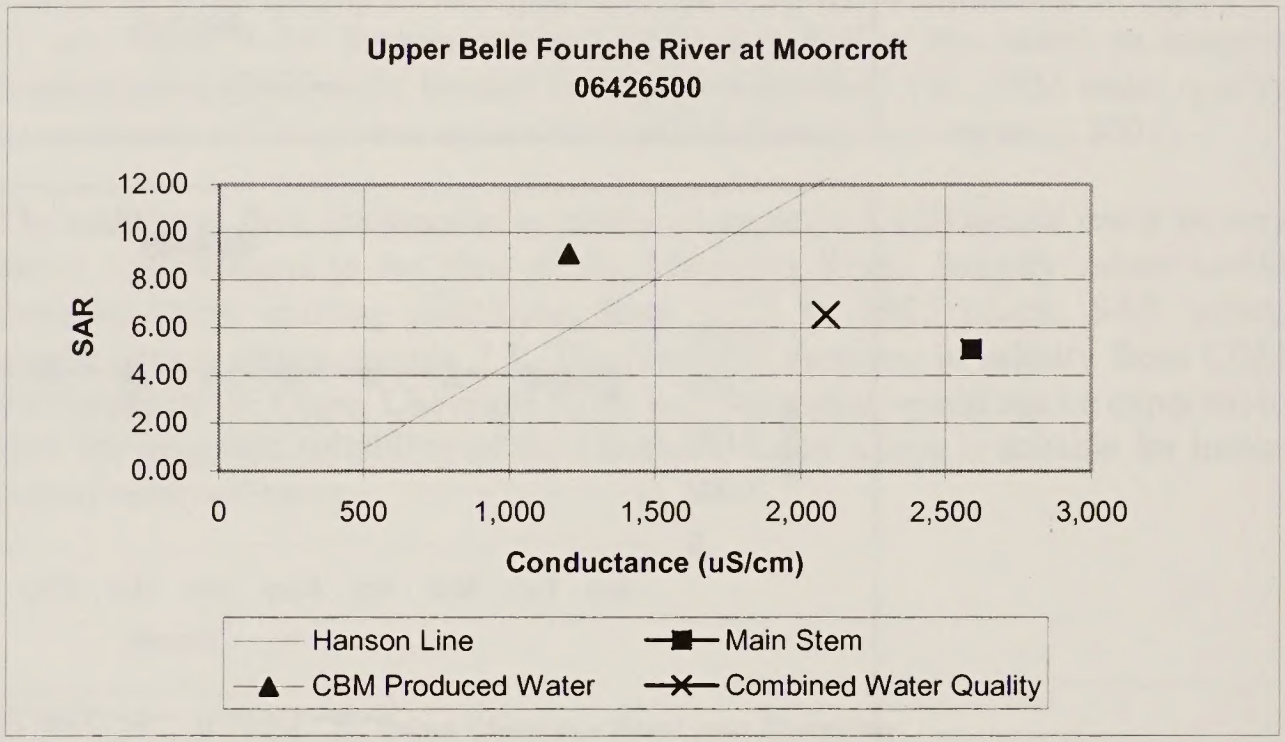
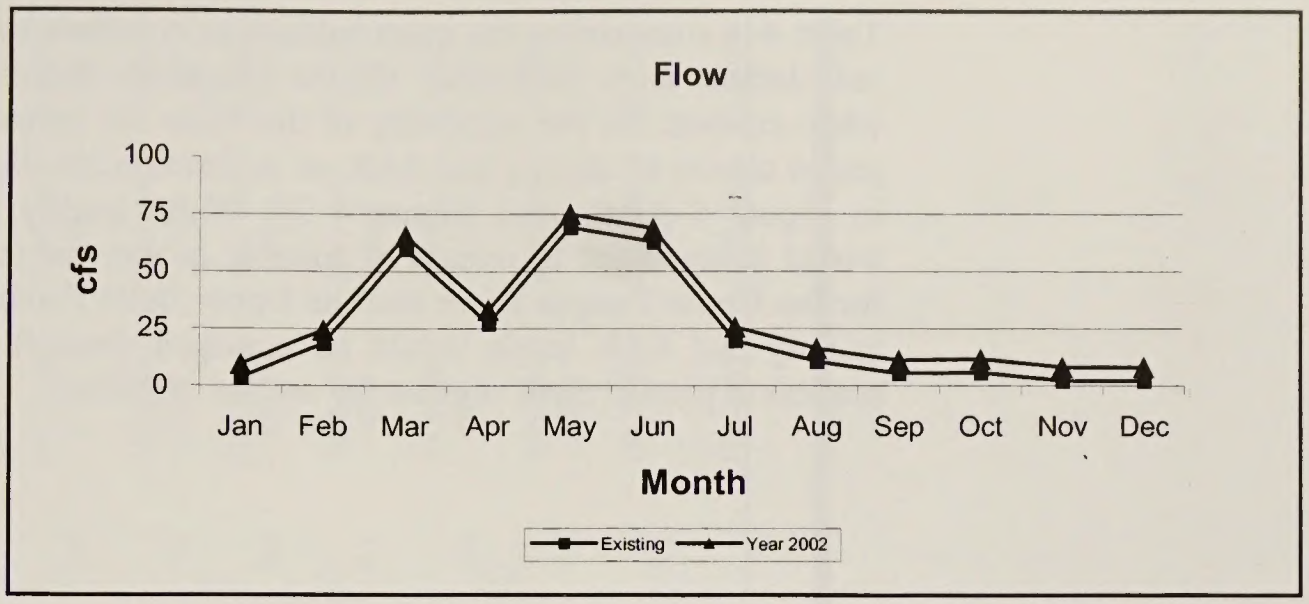
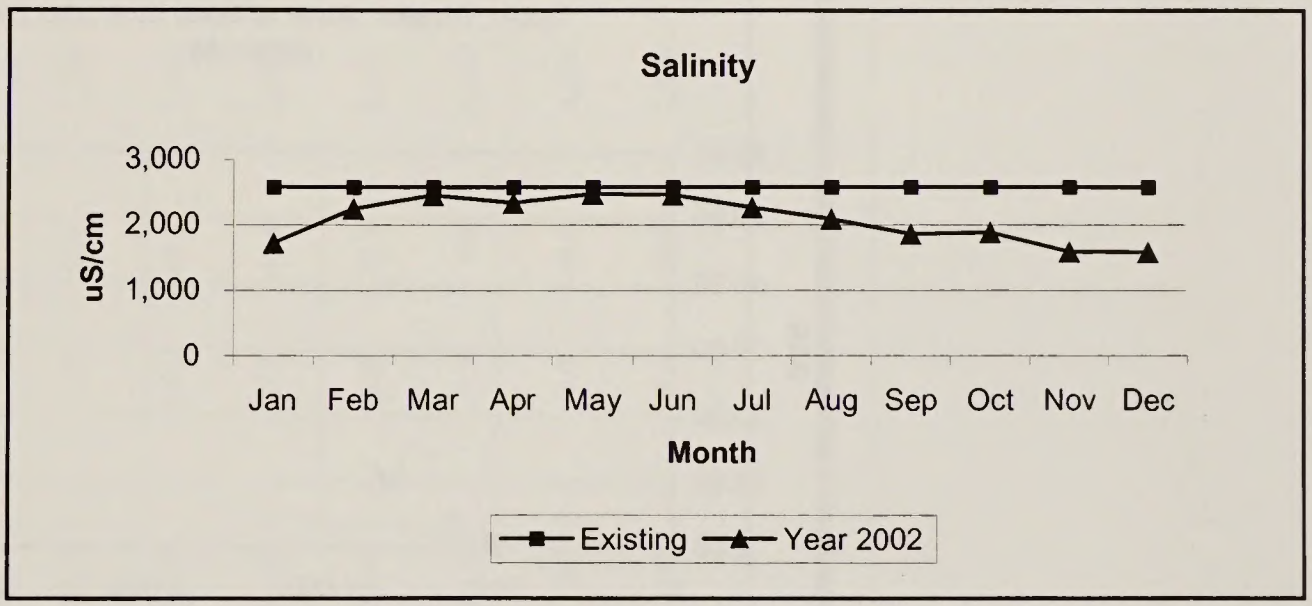


Figure 4–29 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Upper Belle Fourche River Sub-Watershed

The additional flow attributable to produced water (5.9 cfs) would result in very minor contributions to the flow of the Upper Belle Fourche River. Salinity values would decrease below existing conditions, from 2,588 to 2,087 µS/cm. SAR values would increase from 5.1 to 6.5. The projected decrease in salinity and increase in SAR would not alter the irrigation suitability of the Belle Fourche River as both values would approach baseline levels during irrigation months. The combined water quality would be expected to be suitable for irrigation, based on Year 2002 projections.

Over the life of the project, effects on surface water quality and the suitability of surface waters for irrigation purposes, when commingled with CBM discharges, are expected to be comparable to the effects illustrated in the year 2002, assuming the water handling percentages remain unchanged. Mass balance calculations were performed using the same methodology and assumptions described earlier in this section for Year 2002 impacts. These mass balance calculations assume that the representative water quality of the CBM discharges and surface water quality and stream flows remain constant throughout the life of the Project.





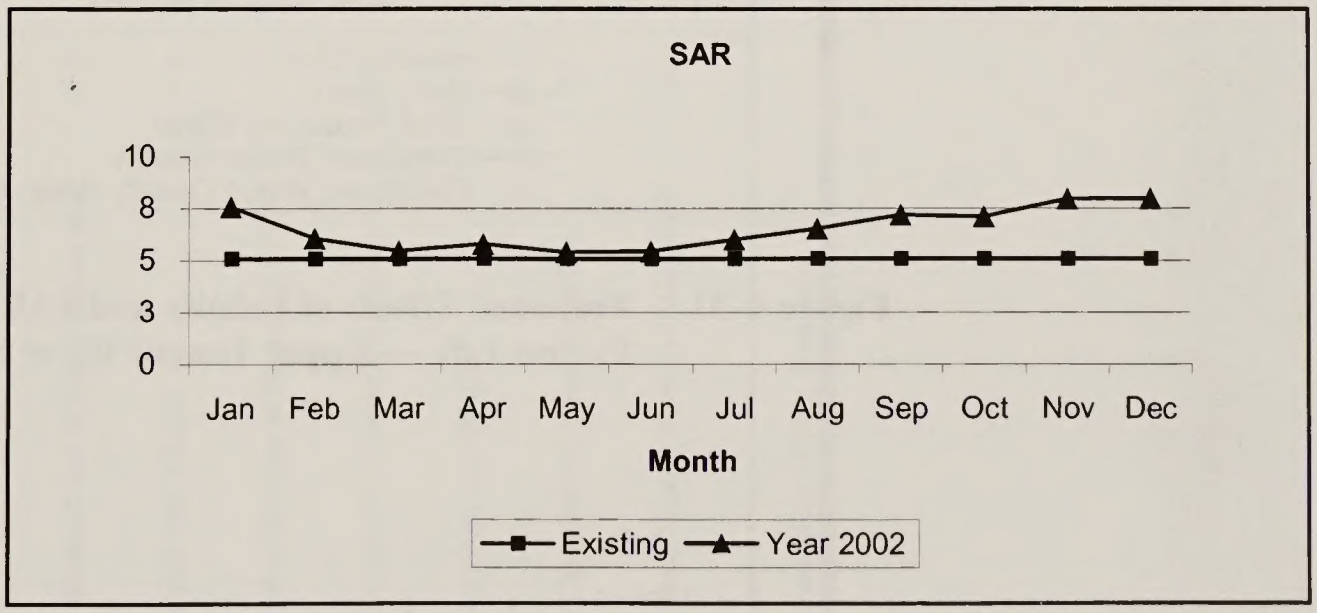


Figure 4–30 Existing and Projected Water Quality Effects in Year 2002 — Upper Belle Fourche River Sub-Watershed

Table 4–6 summarizes the mass balance calculations by sub-watershed. Separate calculations were performed for the irrigations months of May through July, when concern for the suitability of the water for irrigation is greatest. The projected effects of salinity and SAR on infiltration are illustrated by sub-watershed in Figure 4–31 through Figure 4–39. Water quality in the receiving streams would be expected to remain of suitable quality for irrigation purposes, except for the Upper Tongue River and the Upper Belle Fourche River. Restrictions on salinity and SAR levels would be managed through the WDEQ's permitting process to protect these streams for use for irrigation.

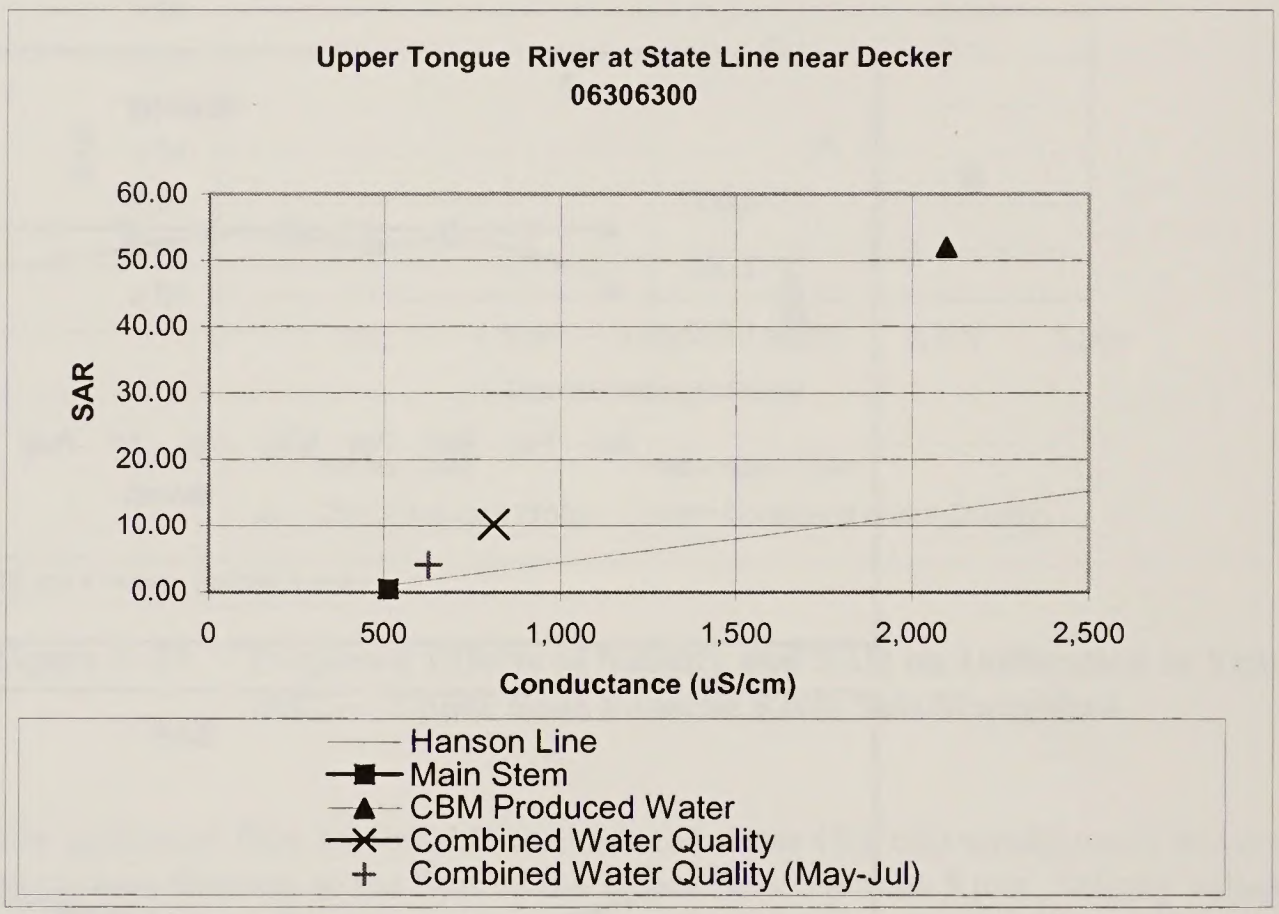


Figure 4–31 Projected Effects of Salinity and SAR on Infiltration over Project Life — Upper Tongue River Sub-Watershed

Table 4–6 Projected Surface Flows and Water Quality at Sub-watershed Boundary — Project Life

Sub-Watershed	Station	Predicted CBM Discharge (cfs)	Mean CBM Conductance (uS/cm)	Mean CBM SAR	Mean Stream Flow (cfs)	Mean Stream Conductance (uS/cm)	Mean Stream SAR	Combined Flow (cfs)	Combined Conductance (uS/cm)	Combined SAR
Upper Tongue River	Upper Tongue River at State Line near Decker	67.3	2,099	52.0	460.0	513	0.5	527.3	811	10.2
								1122 (Irr)[1]	627 (Irr)	4.2 (Irr)
Upper Powder River	Upper Powder River at Arvada	342.4	2,428	13.5	277.2	2,057	4.8	619.6	2286	10.2
								932.0 (Irr)	2204 (Irr)	8.3 (Irr)
Crazy Woman Creek	Crazy Woman Creek at Upper Station near Arvada	61.0	2,428	13.5	51.6	1,185	2.0	112.6	1981	9.4
								198.6 (Irr)	1622 (Irr)	6.0 (Irr)
Clear Creek	Clear Creek near Arvada	75.0	2,428	13.5	187.5	1,141	1.1	262.5	1620	5.7
								517.3 (Irr)	1367 (Irr)	3.3 (Irr)
Middle Powder River	Middle Powder River at Moorhead, MT	16.7	3,423	3.7	462.5	2,023	4.4	479.2	2103	4.4
								1025 (Irr)	2051 (Irr)	4.4 (Irr)
Little Powder River	Little Powder River above Dry Creek near Weston	18.8	2,048	8.9	22.3	2,737	6.1	41.1	2346	7.7
								53.1 (Irr)	2450 (Irr)	7.3 (Irr)
Antelope Creek	Antelope Creek near Teckla	17.3	1,130	7.3	9.8	2,920	3.0	27.1	1537	6.3
								47.3 (Irr)	2120 (Irr)	4.9 (Irr)
Upper Cheyenne River	Upper Cheyenne River near Riverview	5.2	787	7.0	58.0	3,321	7.3	63.2	2478	7.2
								185.5 (Irr)	3245 (Irr)	7.3 (Irr)
Upper Belle Fourche River	Upper Belle Fourche River near Moorcroft	54.0	1,202	9.1	23.9	2,588	5.1	77.9	1546	8.1
								123.2 (Irr)	1834 (Irr)	7.3 (Irr)

Notes:
1 Irr = Projected during the irrigation months of May, June, July

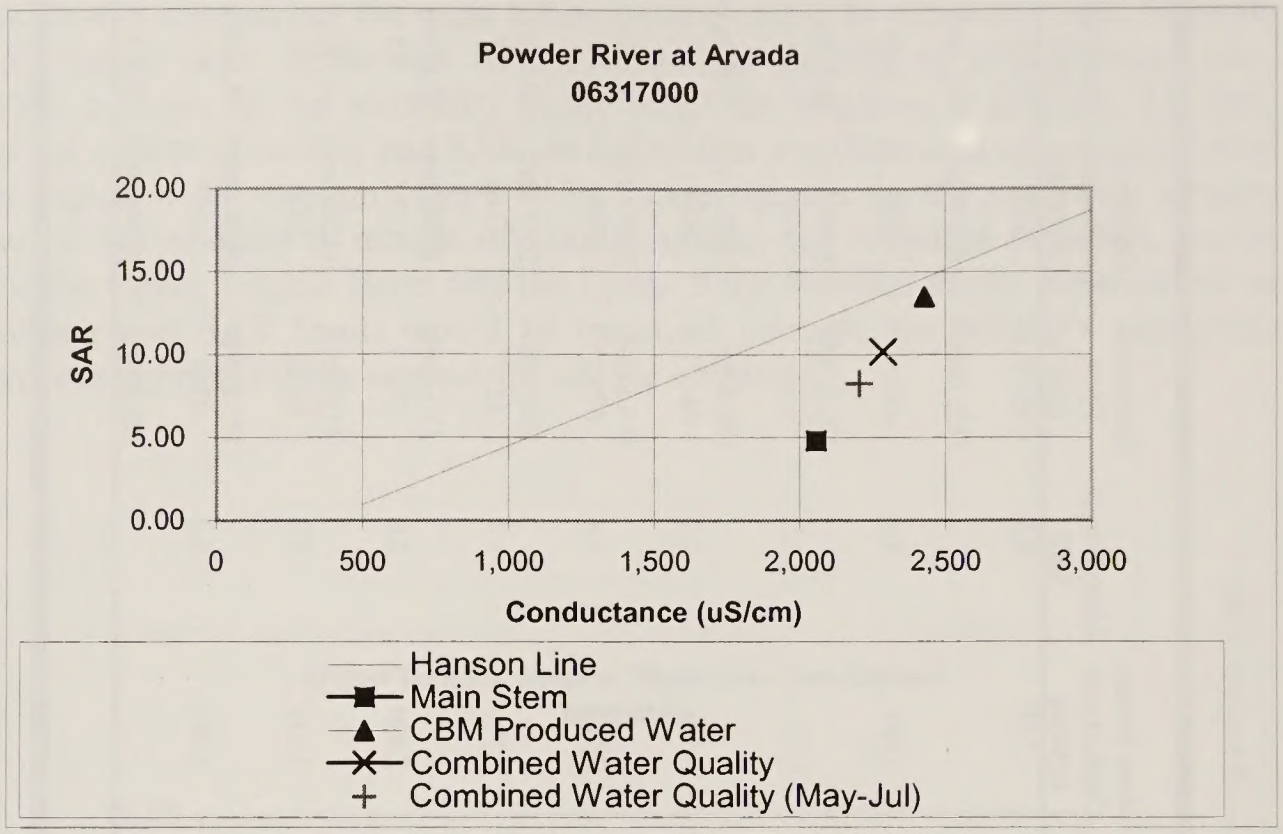


Figure 4–32 Projected Effects of Salinity and SAR on Infiltration over Project Life — Upper Powder River Sub-Watershed

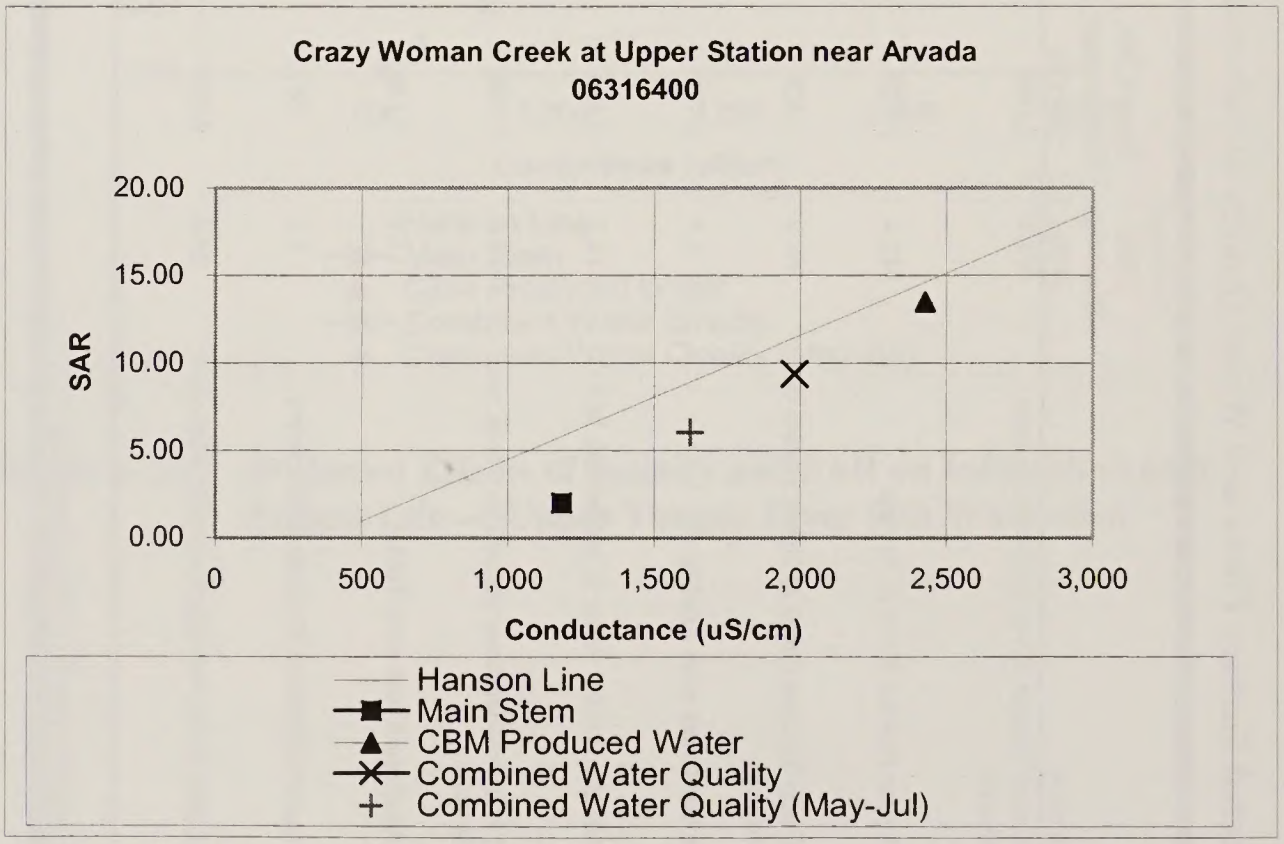


Figure 4–33 Projected Effects of Salinity and SAR on Infiltration over Project Life – Crazy Woman Creek Sub-Watershed

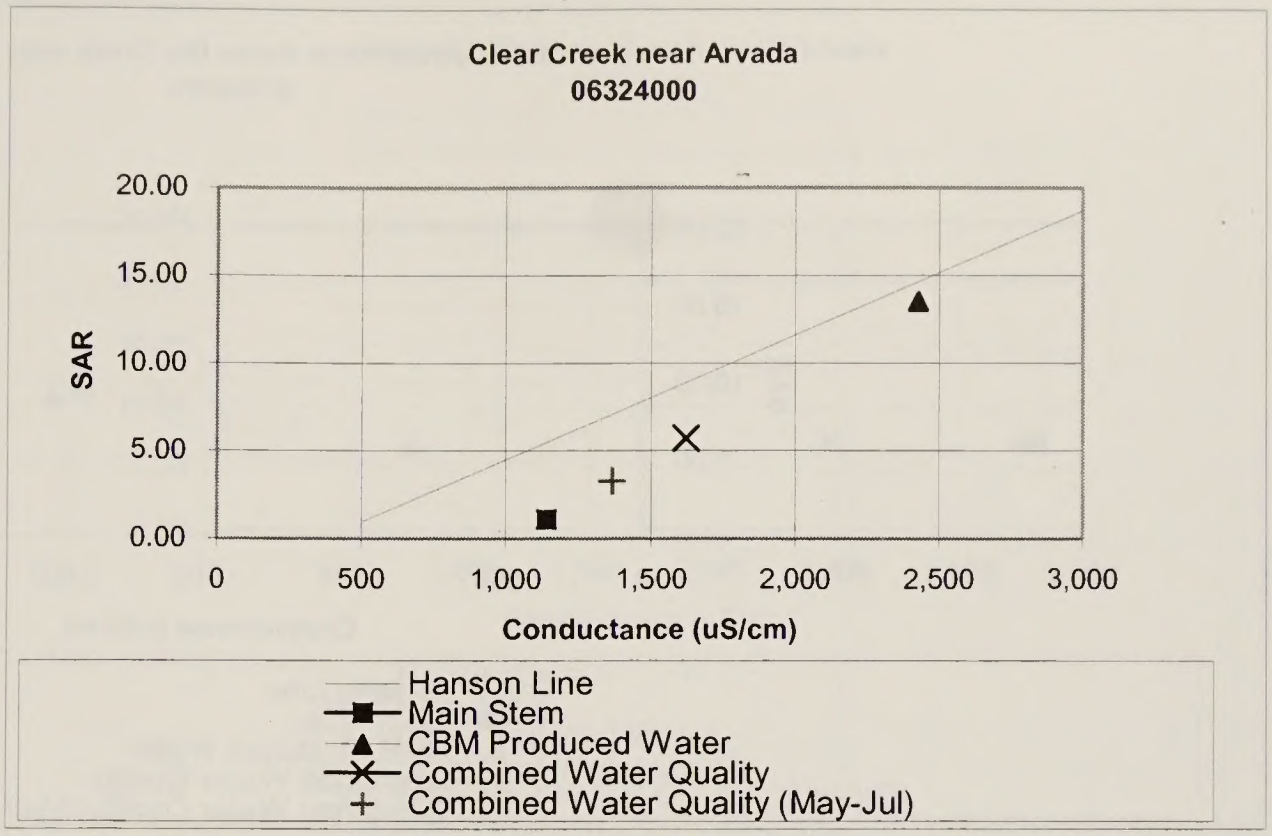


Figure 4–34 Projected Effects of Salinity and SAR on Infiltration over Project Life – Clear Creek Sub-Watershed

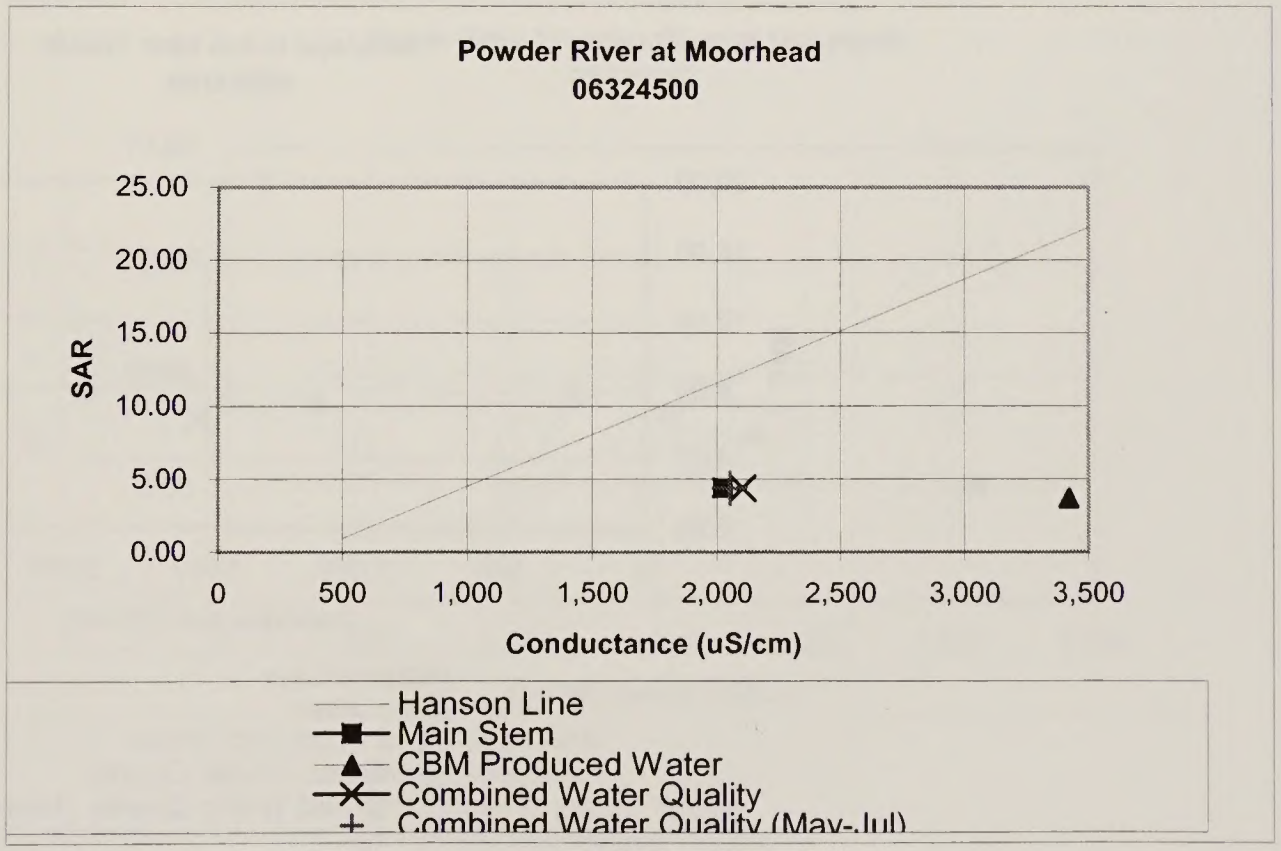


Figure 4–35 Projected Effects of Salinity and SAR on Infiltration over Project Life – Middle Powder River Sub-Watershed

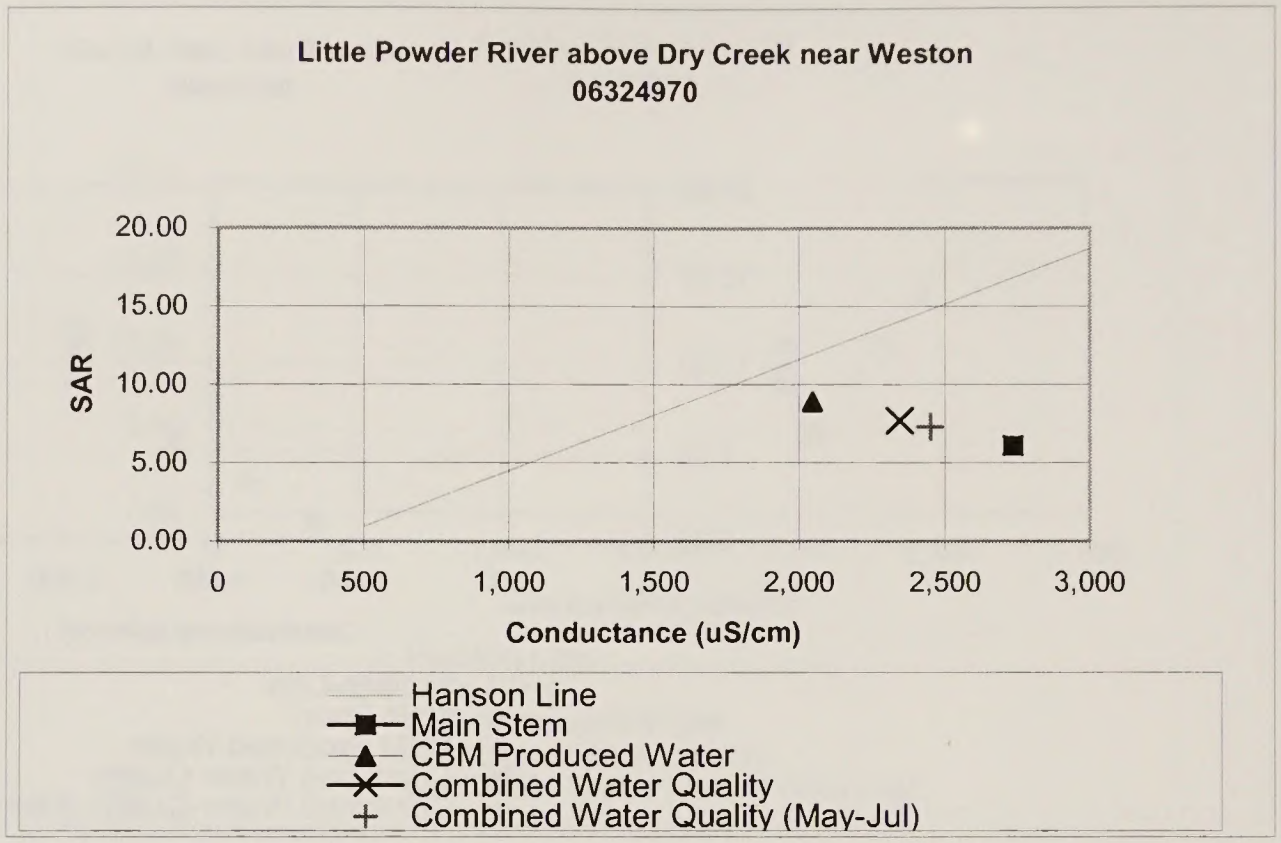


Figure 4–36 Projected Effects of Salinity and SAR on Infiltration over Project Life – Little Powder River Sub-Watershed

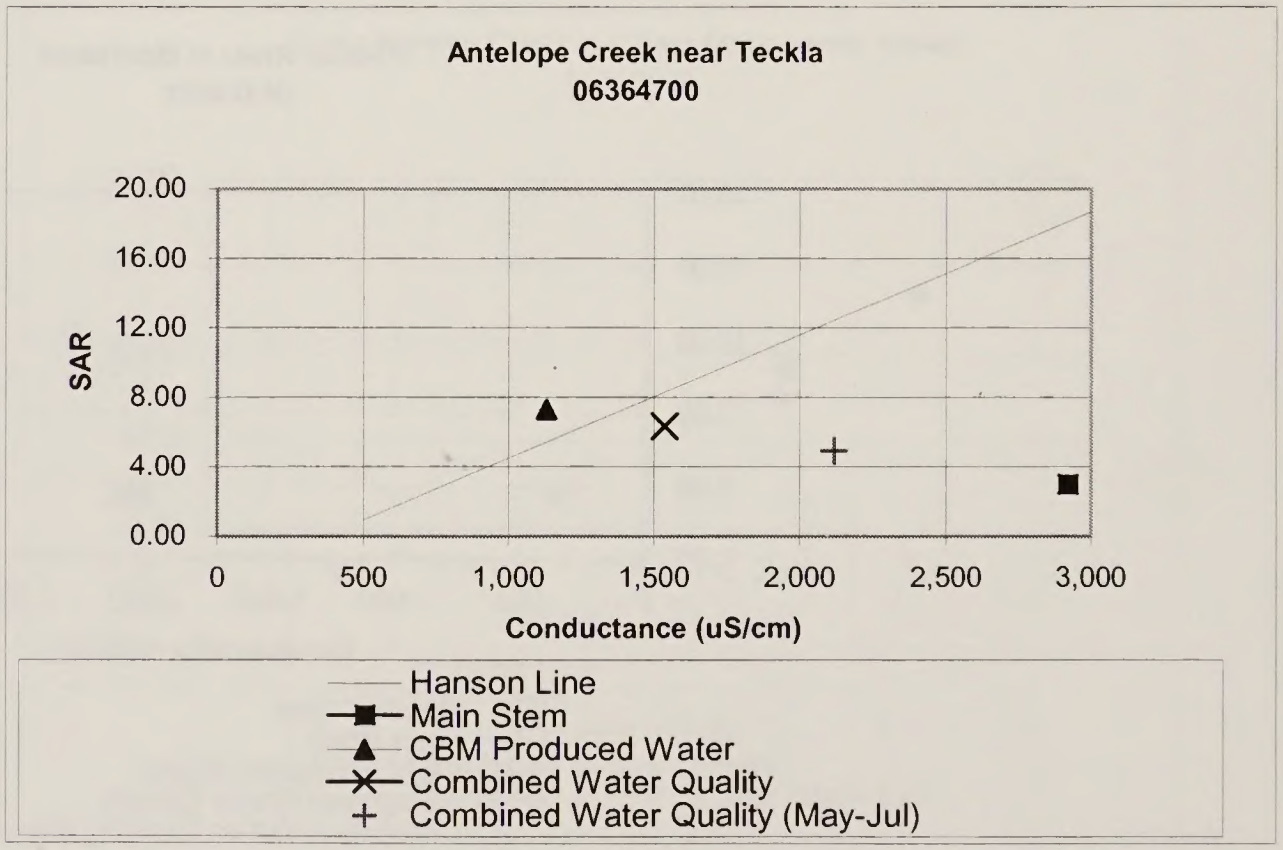


Figure 4–37 Projected Effects of Salinity and SAR on Infiltration over Project Life – Antelope Creek Sub-Watershed

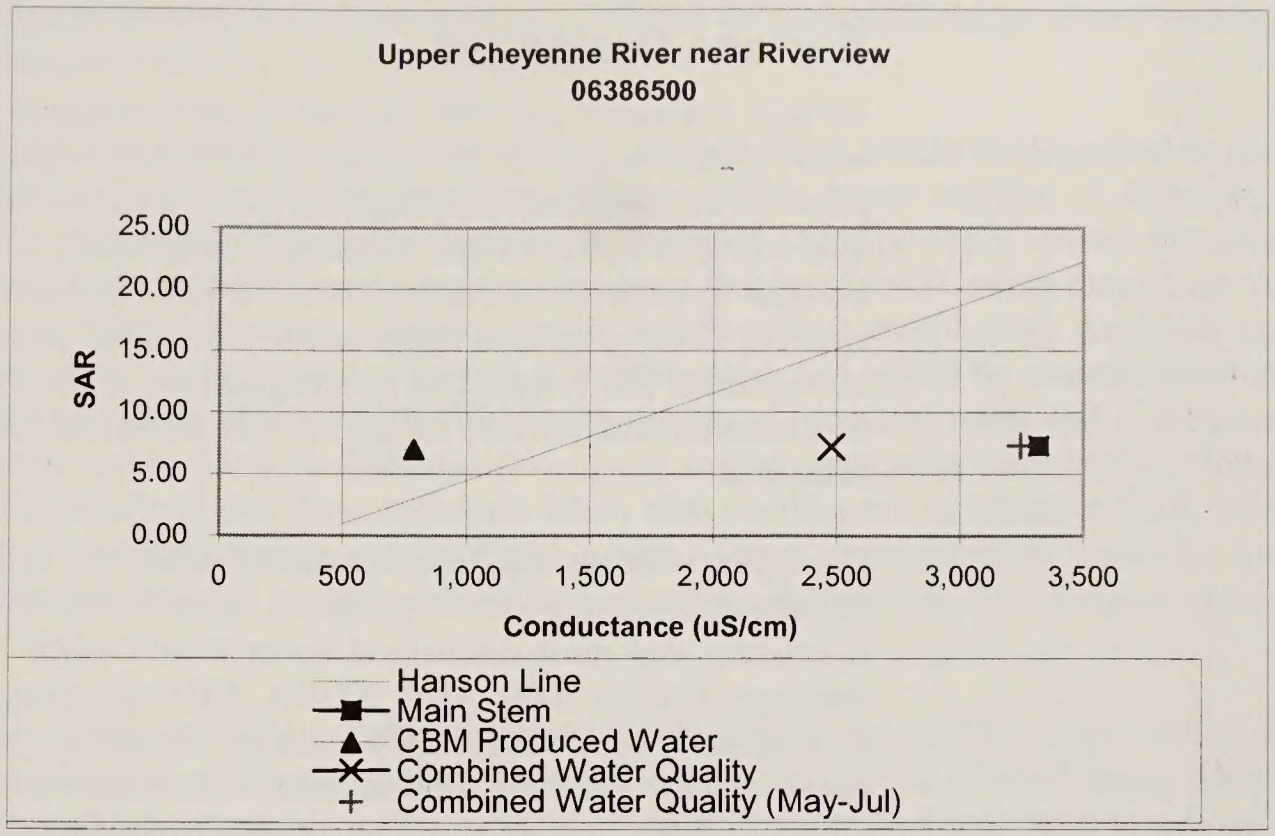


Figure 4–38 Projected Effects of Salinity and SAR on Infiltration over Project Life –Upper Cheyenne River Sub-Watershed

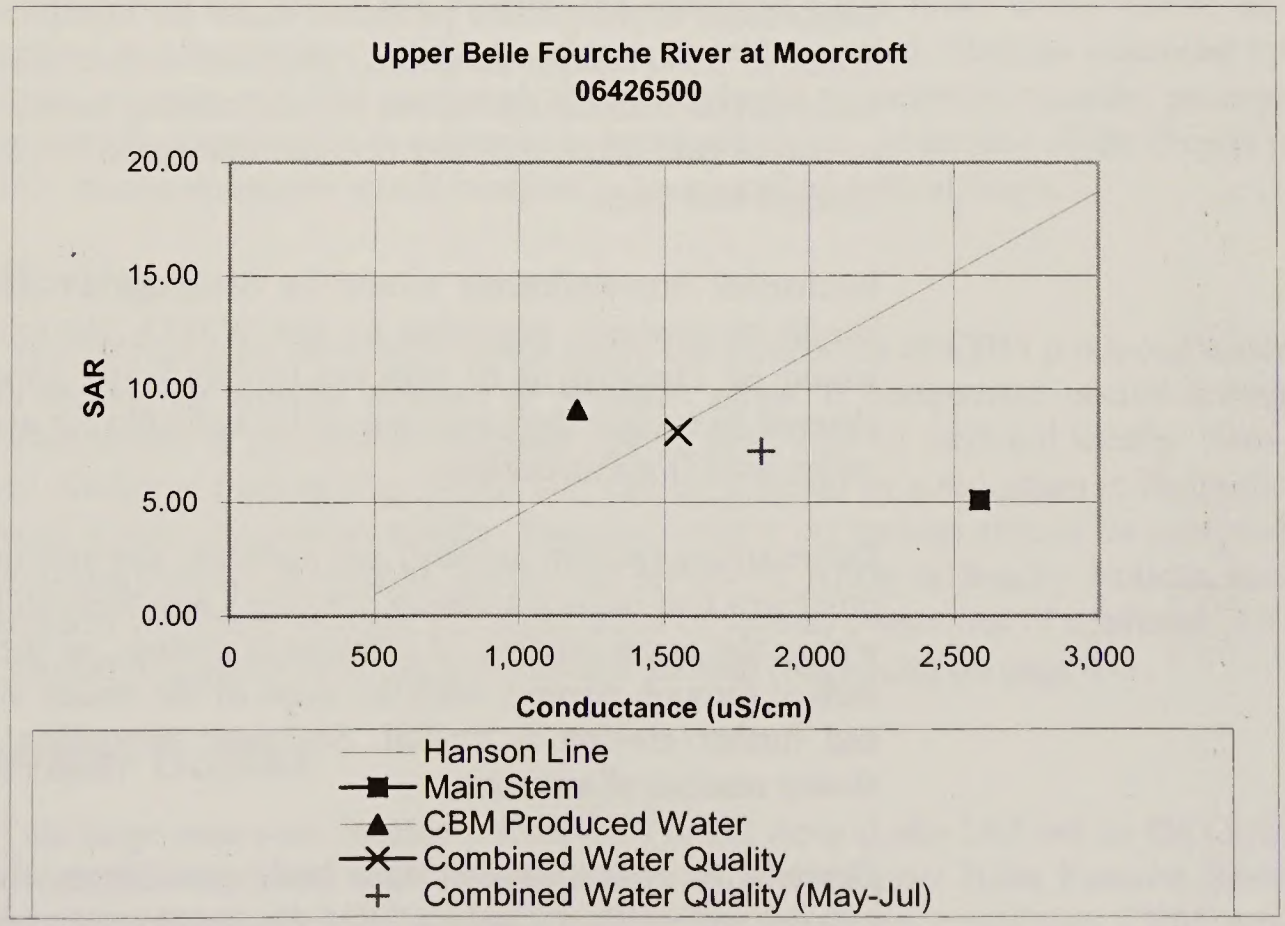


Figure 4–39 Projected Effects of Salinity and SAR on Infiltration over Project Life –Upper Belle Fourche River Sub-Watershed

Surface Drainages

Surface drainages may be affected by the discharge of CBM produced water where channels are not stable, armored, or large enough to accommodate anticipated flows. Localized flooding may occur with increased frequency and magnitude where channel or basin capacity is insufficient to handle increased flows. In contrast to naturally occurring flows, which fluctuate drastically with changing seasons, CBM generated flows occur year-round with small fluctuations. Water management plans would be an integral part of the mitigation planning to control, monitor, and provide for appropriate beneficial use of CBM produced water in an area.

Conveyance losses due to evapotranspiration and infiltration would reduce the volume of discharged CBM produced water by an estimated 80 percent, making it unlikely that most discharged water would reach the main stems of surface drainages (Meyer 2000, AHA 2001b). Although most of the discharged water in an area likely would not reach a main stem drainage, previously ephemeral draws could become perennial downstream from clustered outfalls, where large volumes of CBM produced water are released to surface drainages.

High seasonal flows during the spring would be expected to rise with the addition of CBM produced water. Channels may overbank during snowmelt, flooding nearby fields. Localized erosion and gully formation, water-damaged structures, inundated vegetation, siltation, or breaching of irrigation structures may result from large, late, or prolonged flood events. However, numerous impoundments constructed to store CBM produced water for beneficial use also would serve as effective flood control structures. Increased surface flows also could fill channels and culverts with ice during the winter, causing localized flooding. Closed basins or playas (old lakebeds) may become inundated if CBM produced water is discharged into them.

In-channel impoundments would be designed as flow-through structures and would be properly permitted by the WSEO. No existing surface water right would be expected to be affected by this water handling method. Water discharged to surface drainages would be available for appropriation and diversion, under WSEO authorizations.

Downcutting (stream erosion) and sediment deposition (aggradation) are natural processes that occur as stream drainages age through time. Downcutting occurs within the upper reaches of a drainage system, as the stream channel becomes incised through erosion, until the slope of the stream and its velocity are reduced and further erosion is limited. Sediment deposition occurs within the lower, slower reaches of a stream.

Degradation of surface drainages could result from stream erosion caused by increased surface flows, unless CBM discharge rates and outfall locations are carefully controlled. Increased flows could cause downcutting in fluvial environments, resulting in increased channel capacity within upper and middle reaches of watersheds over time. Where downcutting occurs in highly erodible soils, ravines or gullies are likely to develop unless outfalls are carefully located and de-

signed. Design should incorporate avoidance of surface discharge above existing headcut areas.

Sediment transported downstream from outfalls likely would be deposited in fluvial settings, as stream gradients decrease within lower reaches of drainages. Wherever sediment deposition occurs, channel capacity likely would decrease over time, possibly increasing the likelihood that localized flooding may occur. A new balance between channel capacity and floodplain morphology would be established as the proposed Project is implemented, and would be re-established at the end of the Project's life. Where the quality of produced water and landowner preferences allow the construction of stock reservoirs to store some surface flows for beneficial use, these structures likely also would serve as effective flood control measures during intense storm events. These impoundments would be located in-channel or near-channel and would be designed as flow through structures.

Overbank deposits (produced during flood events) can yield nutrient-rich and arable soils, which may enhance the agricultural uses of the affected lands. Alternatively, overbank deposits may add saline or fine-grained sediments to a floodplain, decreasing productivity and lowering infiltration rates through the addition of materials having elevated SAR values. The latter could occur in watersheds affected by saline soils, soils developed from shales, or CBM produced water containing elevated SAR values.

While drainages would not be expected to flow under completely natural conditions during the life of the Project, the enhanced CBM flows would not be expected to alter surface drainage patterns, except as noted. Streams enhanced by large volumes of CBM produced water may begin to establish meander patterns on longer wavelengths in response to increased flows. At the end of the Project's life, stream drainages would readjust to their existing natural flows.

Springs

New springs may develop in areas where the infiltration of CBM produced water is recharging alluvial aquifers or Wasatch sands. If compaction occurs during construction or production activities, spring flow may be inhibited locally. Natural discharge from springs potentially can be affected by a reduction in hydraulic head within the source aquifer. Potential effects on springs should be analyzed site-specifically, as needed, during the review of APDs or Sundry Notices, and impacts mitigated through the application of special conditions of approval. Additional discussion is in the groundwater section (beginning on page 4–1.

Water Bodies

Two large reservoirs located within the Project Area (Lake DeSmet in the Clear Creek sub-watershed and Keyhole Reservoir in the Upper Belle Fourche River sub-watershed) potentially would receive surface flows containing CBM produced water. More than half of the smaller 1,161 permitted surface water impoundments in the Project Area would also potentially receive surface flows containing CBM produced water. Concentrations of trace metals and salts in the impounded water may become elevated as evaporation occurs. Water quality could reach levels of concern for various constituents when inflow to the impound-

ments cease, and prior to reclamation. Evaporation of pond contents with no additional inflow of CBM water could be expected to elevate constituent concentrations by as much as 20 percent each year until the contents are dry. The water chemistry, sediment load, and flow quantity of CBM produced water that may reach surface water impoundments should be carefully monitored and addressed in water management planning for each area affected by CBM development. Potential effects on surface water impoundments should be analyzed site-specifically, as needed, during the review of APDs or Sundry Notices, and impacts mitigated through the application of special conditions of approval.

Surface Water Use

Produced water from CBM wells is most likely to be used for livestock watering, fisheries, and irrigation. Dust abatement of county roads is likely to be accomplished using CBM water in minimal amounts. Surface water withdrawals in the Project Area totaled 1,636 mgd in 1995 (USGS 1995). The total volume of water that would be produced during the life of the Project is estimated to be 4.4 million acre-feet. Conveyance losses of 80 percent due to evapotranspiration and infiltration along stream channels would result in approximately 476,000 acre-feet of CBM produced water available for withdrawal over the life of the Project.

Alternative 2A

Under Alternative 2A, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences resulting from changes in the distribution of water handling options (discussed below), the effects on surface water resources would be similar to those described under Alternative 1.

The distribution of water handling methods under Alternative 2A is summarized in Table 2-9. The percentage of water handled by each of these options as a percentage of the total water production is summarized on Table 4–2. Alternative 2A emphasizes discharge of CBM water to infiltration impoundments, accounting for 20 to 40 percent of the total water production. The maximum water volume discharged to the surface under Alternative 2A is expected to increase from an estimated 66,000 acre-feet in 2002, to an estimated 83,000 acre-feet, occurring in 2006. The volume of CBM water discharged to surface drainages is less than under Alternative 1. There would be no surface discharge in the Salt Creek sub-watershed. The projected annual outflow of CBM produced water at the sub-watershed boundaries also would be less than under Alternative 1, as shown on Table 4–1.

CBM supplemented flows at the sub-watershed boundaries would account for between 0.2 and 13 percent of the annual average stream flows, as shown on Table 4–2. CBM supplemented flows at the sub-watershed boundaries would be less than under Alternative 1 in all sub-watersheds except the Upper Belle Fourche River sub-watershed, which would remain unchanged from Alternative 1.

Water quality of the receiving streams may improve because of the increased use of passive treatment of CBM water prior to surface discharge. The water quality

of the receiving streams is likely to remain suitable for irrigation purposes. The volume of CBM water likely to be used for irrigation, livestock watering, and other beneficial uses would be less than under Alternative 1, with approximately 179,000 acre-feet available for use over the life of the project.

Alternative 2B

Under Alternative 2B, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences resulting from changes in the distribution of water handling options (discussed below), the effects on surface water resources would be similar to those described under Alternative 1.

The distribution of water handling methods under Alternative 2B is summarized in Table 2–9. The percentage of water handled by each of these options as a percentage of the total water production is summarized on Table 4–3. Alternative 2B emphasizes treatment, both passive and active, prior to surface discharge of CBM water. The maximum water volume discharged to the surface under Alternative 2B is expected to increase from an estimated 107,000 acre-feet in 2002, to an estimated 146,000 acre-feet, occurring in 2006. The volume of CBM water discharged to surface drainages would be less than under Alternative 1, but more than under Alternative 2B. There would be no surface discharge in the Salt Creek sub-watershed. The projected annual outflow of CBM produced water at the sub-watershed boundaries also would be less than Alternative 1, but would be more than under Alternative 2A, as shown on Table 4–1.

CBM supplemented flows at the sub-watershed boundaries would account for between 0.1 and 14 percent of the annual average stream flows, as shown on Table 4–3. CBM supplemented flows at the sub-watershed boundaries would decrease from Alternative 1 in all sub-watersheds except the Upper Belle Fourche River sub-watershed, which would increase from Alternative 1.

Water quality of the receiving streams would likely improve and increase assimilative capacity because of the increased use of treatment of CBM water prior to surface discharge. The water quality of the receiving streams would likely remain suitable for irrigation purposes. The volume of CBM water likely to be used for irrigation, livestock watering, and other beneficial uses would be less than under Alternative 1, but more than under Alternative 2A, with approximately 271,000 acre-feet available for use over the life of the Project. It is likely that consumptive use of CBM water would increase as the water would be of higher quality due to the treatment methods employed prior to discharge.

Alternative 3

Alternative 3 (No Action) assumes that no new Federal wells would be completed, except for potential drainage situations. This would result in a substantial reduction in projected new CBM wells, from 39,367 to 15,458. Except for the differences discussed below, the effects on surface water resources would be similar to those described under Alternative 1.

The maximum water volume discharged to the surface under Alternative 3 is expected to increase from an estimated 36,000 ac-ft in 2002, to an estimated 112,000 ac-ft, occurring in 2007. The volume of CBM water discharged to surface drainages would be less than under Alternative 1. The projected annual outflow of CBM produced water at the sub-watershed boundaries also would be less than Alternative 1, as shown on Table 4–1.

CBM supplemented flows at the sub-watershed boundaries would account for between 0.02 and 6 percent of the annual average stream flows, as shown on Table 4–3. CBM supplemented flows at the sub-watershed boundaries would be less than under Alternative 1 in all sub-watersheds except the Salt Creek sub-watershed, which would remain unchanged from Alternative 1.

The water quality of the receiving streams would likely remain suitable for irrigation purposes. The volume of CBM water likely to be used for irrigation, livestock watering, and other beneficial uses would decrease under Alternative 3, with approximately 182,000 acre-feet available for use over the life of the Project.

Cumulative Effects

Alternative 1

Surface Water Quantity

The cumulative surface water flows at the Project Area boundaries are shown in Table 4–7. CBM-enhanced surface flows from the following sub-watersheds would be combined, as outflow from the Powder River at the Montana State line: Salt Creek; Upper Powder River; Crazy Woman Creek; Clear Creek, and Middle Powder River. CBM-enhanced surface flows from the following sub-watersheds would not be combined with any other sub-watersheds, and each would represent a separate outflow at the Montana State line: Upper Tongue River and Little Powder River. CBM-enhanced surface flows from the Upper Belle Fourche River sub-watershed would not be combined with any other sub-watersheds, and would represent a separate outflow at the eastern Project Area boundary. CBM-enhanced surface flows from the following sub-watersheds would be combined, as outflow from the Cheyenne River at the eastern Project Area boundary: Antelope Creek; and Upper Cheyenne River.

Active coal mines would have additional surface water to manage. Active coal mines are located within three sub-watersheds in the Project Area: the Upper Belle Fourche River, Little Powder River, and Upper Cheyenne River sub-watersheds. Culverts carrying water from upstream reaches of watersheds undergoing CBM development may have to be re-sized. Diversion channels for natural flows may have to be re-sized to handle additional flows. Mining operations that partially treat water in their sedimentation impoundments may have additional water to treat. In these situations, the water quality at the mines' NPDES outfalls may be affected by commingling CBM discharge waters with those from the surface mines. Potential effects on mine operations should be analyzed site-specifically, as needed, during the review of CBM Plans of Development and/or Water Management Plans, and impacts mitigated through

Water Management Plans, and impacts mitigated through the application of special conditions of approval for affected APDs.

Table 4–7 Cumulative Surface Water Volume and Flow at Project Boundary

Sub-Watershed	Cumulative CBM Enhanced Surface Water Volume at Project Boundary (acre-feet)	Cumulative CBM Enhanced Surface Water Flow at Project Boundary (cfs)
Alternative 1		
Upper Tongue River at State Line near Decker, WY	51,210	71
Upper Powder River at Arvada, WY		
Salt Creek near Sussex, WY		
Crazy Woman Creek at Upper Station near Arvada, WY		
Clear Creek nr Arvada, WY		
Middle Powder River at Moorhead, MT	370,923	512
Little Powder River above Dry C near Weston, WY	15,581	22
Antelope Creek near Teckla, WY		
Upper Cheyenne River near Riverview	17,323	24
Upper Belle Fourche River below Moorcroft, WY	43,550	60
Alternative 2A		
Upper Tongue River at State Line near Decker, WY	14,632	20
Upper Powder River at Arvada, WY		
Salt Creek near Sussex, WY		
Crazy Woman Creek at Upper Station near Arvada, WY		
Clear Creek nr Arvada, WY		
Middle Powder River at Moorhead, MT	113,203	156
Little Powder River above Dry C near Weston, WY	5,993	8.3
Antelope Creek near Teckla, WY		
Upper Cheyenne River near Riverview	12,598	17
Upper Belle Fourche River below Moorcroft, WY	43,550	60
Alternative 2B		
Upper Tongue River at State Line near Decker, WY	38,407	53
Upper Powder River at Arvada, WY		
Salt Creek near Sussex, WY		
Crazy Woman Creek at Upper Station near Arvada, WY		
Clear Creek nr Arvada, WY		
Middle Powder River at Moorhead, MT	177,341	245
Little Powder River above Dry C near Weston, WY	8,629	12
Antelope Creek near Teckla, WY		
Upper Cheyenne River near Riverview	12,598	17
Upper Belle Fourche River below Moorcroft, WY	48,389	67
Alternative 3		
Upper Tongue River at State Line near Deeker, WY	21,894	30
Upper Powder River at Arvada, WY		
Salt Creek near Sussex, WY		
Crazy Woman Creek at Upper Station near Arvada, WY		
Clear Creek nr Arvada, WY		
Middle Powder River at Moorhead, MT	163,396	226
Little Powder River above Dry C near Weston, WY	16,265	23
Antelope Creek near Teckla, WY		
Upper Cheyenne River near Riverview	10,339	14
Upper Belle Fourche River below Moorcroft, WY	35,516	49

Surface Water Quality

The cumulative impacts on surface water resources from activities associated with CBM development and surface coal mining activities are considered in mass balance calculations of CBM and mine surface discharge from each sub-watershed and existing water quality and flow data. The calculations were per-

formed to provide an estimate of the cumulative effects on salinity and SAR expected at the Project boundary. Mass balance calculations were performed using the same methodology described earlier in this section for Project-only impacts, with the following exceptions. WDEQ files indicate that coal mine discharges do not occur regularly. Typically, coal mine discharges occur only in response to large storm events, when sedimentation ponds require dewatering. Discharge monitoring reports do not contain parameters needed to evaluate salinity or SAR for mine discharge waters. TDS values in the sedimentation ponds from surface coal mines were available for a few mines from on-site inspection records. TDS values of these sedimentation ponds average 1,500 mg/L in the Upper Belle Fourche sub-watershed, 1,600 mg/L in the Upper Cheyenne River sub-watershed, and 2,950 mg/L in the Little Powder River sub-watershed. Since the water being discharged by the mines has been extracted from the coal aquifer, it is likely that the representative coal aquifer water quality data in Table 3-2 would represent the salinity and SAR of the mine discharge waters, even though mine water that is discharged in response to storm events is likely to show the effects of mixing with precipitation and sediment from the mine area. Since discharges of CBM water are relatively constant, it is likely that the intermittent surface discharge from coal mining activities would not cause any discernible effects in water quality, with respect to CBM discharges.

Cumulative effects analyzed in the Powder River at Moorhead, Montana for the Salt Creek, Upper Powder River, Crazy Woman Creek, Clear Creek, and Middle Powder River sub-watersheds are represented in Figure 4–40. Cumulative effects analyzed in the Cheyenne River at Riverview, Wyoming for the Upper Cheyenne River and Antelope Creek sub-watersheds are represented in Figure 4–41. Cumulative effects in the Upper Tongue River sub-watershed, the Little Powder River sub-watershed, and the Upper Belle Fourche River sub-watershed would be represented by Figure 4–40 and Figure 4–41, shown previously, as effects would be similar to those projected over the life of the project. Although it was possible to make calculations that would be reasonably representative of the cumulative effects at the Project boundaries, it is not reasonable to project that the assumptions utilized would apply over the life of the Project. Insufficient data are available to compile cumulative water quality data at the Project boundaries. For this reason, the State of Wyoming established a tributary monitoring program in 2001 to collect data from locations where it is needed for meaningful analysis of water quality at the State line. The States of Montana and Wyoming also have agreed to an interim Memorandum of Cooperation MOC) to document their commitments and intent to protect and maintain water quality conditions at the State line. This interstate agreement will include a monitoring program that would provide additional data for evaluating cumulative effects on water quality.

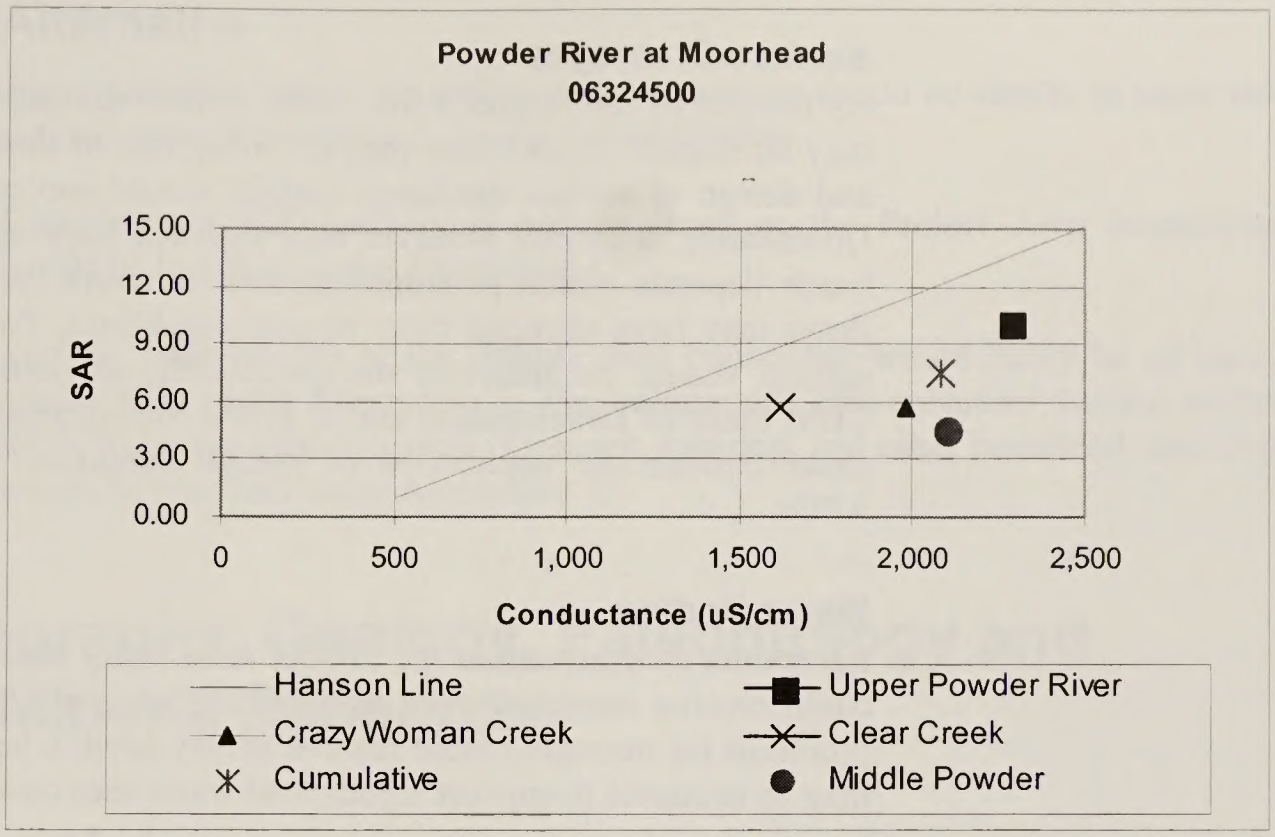


Figure 4–40 Projected Cumulative Effects of Salinity and SAR on Infiltration – Powder River at Moorhead, Montana

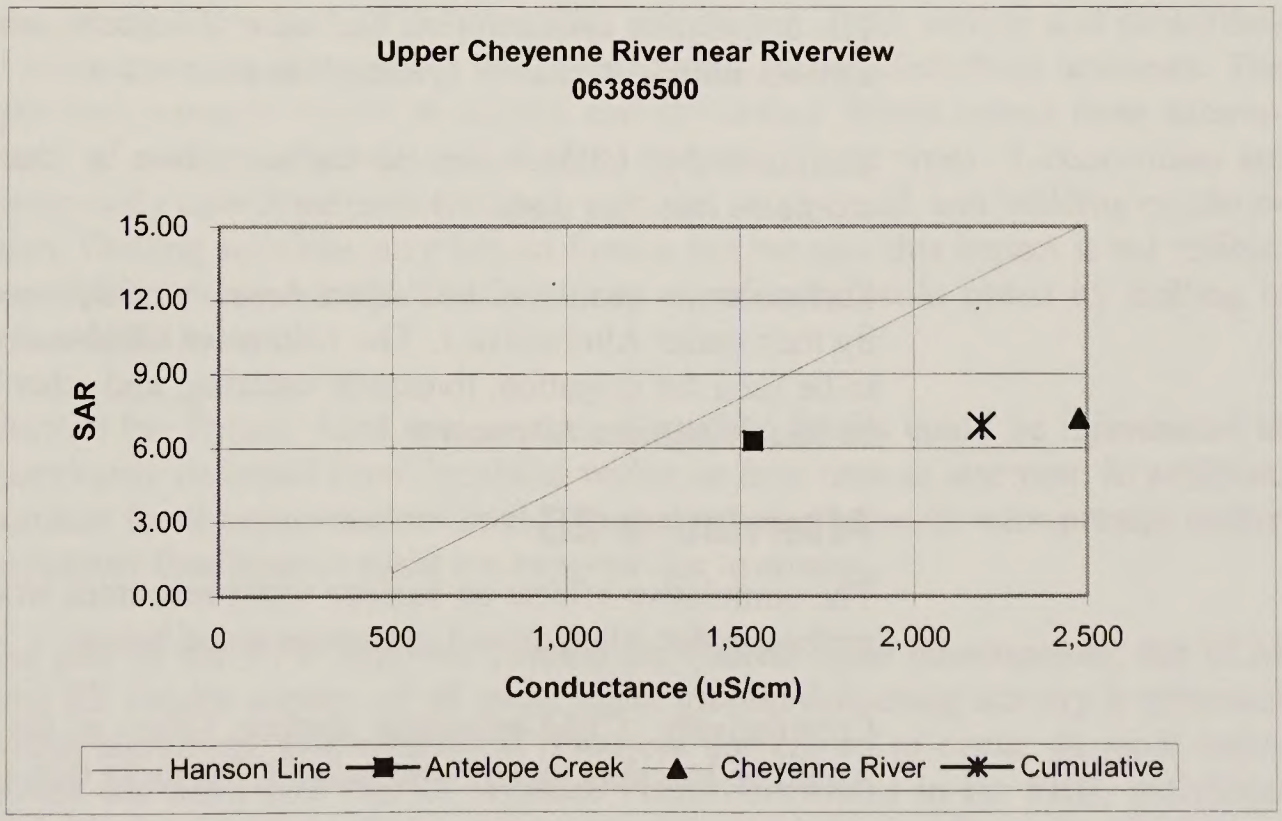


Figure 4–41 Projected Cumulative Effects of Salinity and SAR on Infiltration – Cheyenne River at Riverview, Wyoming

Surface Drainages

By the end of the Project's life, some surface drainages within the Project Area may be slightly deeper than they are today due to stream erosion. Careful siting and design of surface discharge outfalls would prevent or mitigate this impact. Downvalley, a careful observer may feel that there may be a few more bar or beach deposits within perennial streams or rivers than there are today. Spring flows may have changed from present conditions. Potential effects on existing springs should be analyzed site-specifically, as needed, during the review of CBM Plans of Development and/or Water Management Plans, and impacts mitigated through the application of special conditions of approval for affected APDs.

Water Bodies

Reservoirs downstream of the Project Area likely would receive more water and could receive more sediment as a consequence of CBM development. Current protocols for managing these reservoirs may need to be revised. Additional water may be available to support adjudicated water uses downstream of the reservoirs.

Water Use

Agricultural and livestock operations would have additional surface water to manage and use during the life of the Project. Stock watering and irrigation likely would increase within the Project Area. Groundwater withdrawals for these purposes would likely decrease due to the increased availability of surface water.

Alternative 2A

The cumulative effects on surface water resources would be similar to those described under Alternative 1, except as noted below.

Cumulatively, CBM-enhanced surface flows at the Project Area boundaries would be less than under Alternative 1.

Surface water quality at the Project Area boundary would likely be of better quality than under Alternative 1. The volume of CBM-enhanced surface waters likely to be used for irrigation, livestock watering, and other beneficial uses also would be less than under Alternative 1.

Alternative 2B

The cumulative effects on surface water resources would be similar to those described under Alternative 1, except as noted below.

Cumulatively, CBM-enhanced surface flows at the Project Area boundaries would be less than under Alternative 1, but more than under Alternative 2A.

Surface water quality at the Project Area boundaries would likely be of better quality than under Alternatives 1 and 2A. The volume of CBM-enhanced surface waters likely to be used for irrigation, livestock watering, and other beneficial uses also would be less than under Alternative 1, but more than under Alternative 2A.

Alternative 3

The cumulative effects on surface water resources would be similar to those described under Alternative 1, except as noted below.

Cumulatively, CBM-enhanced surface flows at the Project Area boundaries would be less than under Alternative 1.

Surface water quality at the Project Area boundaries would likely be of better quality than under Alternative 1. The volume of CBM-enhanced surface waters likely to be used for irrigation, livestock watering, and other beneficial uses also would be less than under Alternative 1.

Physiography, Geology, Paleontology and Mineral Resources

Paleontology

Paleontological resources are fragile resources and, once disturbed, lose much of their preserved information. Avoidance of significant sites is the preferred mitigation of adverse effects on paleontological resources.

Within the Powder River Basin Project Area, the construction of oil and gas-related facilities, including access roads, could adversely impact scientifically significant fossils. The potential for impact to significant fossils is greatest in areas where Class 3, 4, or 5 formations are present. Both surface and subsurface fossils could be damaged or destroyed during ground-disturbing activities. The greatest potential impact to surface and subsurface fossils comes from excavations of surface sediments and shallow bedrock. These types of excavations are commonly associated with well pad, pipeline, access road, and building construction. Drilling activities may impact fossils, but because this impact is not visible, verifiable or preventable, the impact to significant fossils posed by drilling is considered low.

Across the Project Area, occurrences of surface fossils could be rejuvenated at previously collected fossil localities within as little time as one year. In addition, surface fossil concentrations could develop where no fossils were present before wherever fossiliferous rocks are exposed due to erosion.

As part of the APD approval process for Federal lease development, the BLM and FS require surveys of all areas where ground-disturbing activity is proposed when significant paleontological resources are known to occur. In most cases, given the small size bias of Wasatch Formation fossils in the PRB, individual construction sites should be able to be cleared of all significant fossils prior to construction. APD conditions of approval require protection and prompt reporting of paleontological resources discovered during Project activities. Operations must be suspended until an evaluation of the discovery and mitigation are completed. It is unlikely that any fossils discovered during pre-construction surveys or monitoring phases would result in construction delays. In addition to adverse

impacts during construction, significant fossils may become exposed during subsequent erosion of freshly excavated rocks at each construction site. In Class 3 or 5 formations, post-construction paleontologic inspections may be recommended, depending upon the results of the pre-construction site survey.

All facilities located on Federal surface ownership lands would be considered Federal undertakings, subject to Federal guidelines and regulations protecting paleontological resources. Where oil or gas development excludes Federal leases or surface ownership lands, no Federal permits are required to develop these lands, and protection measures for paleontological resources might not be mandated by the landowners or monitored as closely.

Alternative 1

Development of oil or gas resources on Federal leases would be considered a Federal undertaking, subject to Federal guidelines and regulations protecting paleontological resources. However, only a portion of the facilities associated with Fee and State wells developed under Alternative 1 are likely to be located on Federal surface ownership lands and would be considered Federal undertakings.

Surface disturbance associated with construction activities would increase the potential for paleontological resources to be affected. Only portions of the Project Area have been evaluated for the occurrence of paleontological resources. As a result, no accurate estimate can be made of the number of paleontological sites that may be affected based on the 156 localities that have been recorded.

Surface disturbance typically associated with CBM development in the Project Area, i.e., use of two-track roads and natural terrain without vegetation removal and drill pads or pipelines requiring minimal cut-and-fill excavations, would limit the effect of ground-disturbing activities on subsurface paleontological resources. Although paleontological resources contained in near-surface horizons of soil and surficial deposits likely already have been disturbed by natural processes or human activity, there could be additional disturbance to paleontological resources. Access across natural terrain without vegetation removal and limited use of shallow excavations likely would have minimal additional effect on these resources. Surface use and shallow excavations likely would have little or no effect on undisturbed paleontological resources occurring below the surface.

Where Federal undertakings associated with oil or gas development are involved, potential effects on paleontological resources would be analyzed site-specifically, as needed, during review of APDs, Sundry Notices, ROWs, or Special Use Permits, and effects eliminated or minimized through the application of special conditions of approval for operations. Where direct effects cannot be avoided, an approved data recovery plan would be developed to mitigate the adverse effects.

The development of Fee and State wells would not be considered Federal undertakings, and would not be subject to Federal guidelines and regulations protecting paleontological resources. Unprotected paleontological resources potentially could be disturbed, damaged, destroyed, or removed from the site, losing much or all of their preserved scientific information.

Alternative 2

Effects on paleontological resources likely would be similar to those described under Alternative 1.

Alternative 3

Under Alternative 3, additional development of Federal leases would not be authorized once existing authorizations under the Wyodak CBM Project EIS and the Wyodak Drainage CBM EA have been exhausted. Oil or gas development of Fee and State leases under Alternative 3 would involve far fewer Federal undertakings subject to Federal guidelines and regulations protecting paleontological resources than Alternatives 1 or 2. Consequently, the number of paleontological resources likely to be impacted would be fewer.

Only a portion of the facilities associated with Fee and State wells developed under Alternative 3 are likely to be located on Federal surface ownership lands and would be considered Federal undertakings. Where oil or gas development involves Federal surface ownership lands, effects on paleontological resources likely would be similar to those described under Alternatives 1 and 2.

The development of Fee and State wells under Alternative 3 would not be considered a Federal undertaking, and would not be subject to Federal guidelines and regulations protecting paleontological resources. Unprotected paleontological resources potentially could be disturbed, damaged, destroyed, or removed, losing much or all of their preserved scientific information.

Mineral and Energy Resources

Alternative 1

Methane would be produced from Federal, State, and Fee CBM wells drilled into underlying coal seams in the Project Area. Based on an average production rate of approximately 160,000 cubic feet of CBM per well per day following initial dewatering, and an average of 400 million cubic feet of CBM available per well (De Bruin et al. 2001), an estimated 16 trillion cubic feet of methane would be produced from the CBM wells included in Alternative 1, over the life of those wells. Initial production rates during the first few years of production are expected to be higher, and then steadily decline during the rest of the well's economic life.

CBM development in the PRB has been concentrated on Fee and State leases for several years, causing drainage of CBM resources from Federal leases. Drainage of CBM resources from Federal lease areas would continue to occur under Alternative 1, as development of Federal leases likely would continue to lag behind the development of Fee and State leases. CBM development on Federal leases in some extensively drained areas may no longer be economically feasible. The BLM is continuing to analyze the ongoing and anticipated levels of drainage within the Project Area.

Oil and gas would be produced from non-CBM wells drilled into underlying geologic formations or structures in the Project Area. For the purpose of this analysis, the following assumptions made by the BLM (BLM 2001f) have been used to develop an estimation of the anticipated production of oil and gas from non-CBM wells. Based on a mix of oil and gas discoveries (80 percent of new fields discovered would contain oil and 20 percent of new fields discovered would contain gas), the expected success ratio for the 3,200 new exploratory wells drilled (15 percent), the anticipated number of productive wells (480), the average life of a productive well (15 years), average production of 137,800 barrels of oil equivalent (BOE) over the life of each productive well, and the anticipated average size of new fields (5 wells), an estimated 66,144,000 BOE would be produced from the non-CBM wells included in Alternative 1.

Past conflicts in the Project Area between CBM development and expanding surface coal mining operations indicate potential conflicts may arise. BLM stipulations mandating specific timing of activities or precluding CBM development from some mine areas would be applied unless potential conflicts are resolved through sponsored cooperation among affected interests that would result in mutual agreements for affected areas.

CBM development occurring upstream of nearby surface coal mines could affect coal mining operations. CBM produced water discharged upstream of mines could increase surface flows in the vicinity of coal operations or decrease the rate of groundwater withdrawals currently accompanying ongoing coal mining operations. Changed conditions could affect the design or permitting of coal mining operations and the mining schedule for specific areas.

Sediment control structures located in the coal mine permit areas likely would be affected by increased surface flows anticipated under Alternative 1. These structures have been designed to accommodate historical flow rates that do not include contributions from CBM generated flows. Some design aspects of mining operations may need to be changed. Any required revisions to approved mine plans would impact operators and agencies involved in reviewing proposed changes. Timeframes needed to change design aspects of mining operations may affect the timeframes for initiation of CBM discharges. CBM generated flows are not likely to be lower quality (i.e., have elevated TDS over existing flows). The effects on the availability of groundwater for mining operations and the effects of increased surface flows on mine facilities could be mitigated site-specifically through cooperative agreements among CBM developers and mine operators, as potential effects are identified.

Water production rates, conveyance losses, water chemistry, and water handling methods and their effects have been estimated for sub-watersheds containing surface coal mines. This additional discussion occurs in the surface water section of this chapter. To assist the reader in following this discussion, the relative locations of sub-watersheds, surface coal mines, existing and projected CBM wells, and existing water wells are shown on Figure 2–1.

Although conflicts between CBM drilling and existing or potential surface coal mining may occur, the economic value of the coal resource would not be affected. Development of CBM wells would be precluded in areas of active or im-

pending coal mining. Coal mining before CBM development would result in valuable CBM resources and royalties not being recovered from the mined area.

Locating CBM wells in areas where future mining may take place would preclude mining during the life of CBM wells located in the proposed mining area. Coal in these areas could be mined after CBM extraction is completed or terminated, or after an agreement is negotiated between the CBM developers and the coal mine operators. The effects on mining schedules could be mitigated site-specifically through cooperative agreements among CBM developers and mine operators, as potential effects are identified.

Subsurface uranium deposits located in the southwestern portion of the Project Area are associated with Wasatch Formation sandstones. Withdrawal of CBM and water from the stratigraphically lower Fort Union Formation would not be likely to affect the potential recovery of uranium resources from in-situ (in place) subsurface leaching of sandstones. However, if infiltration of sulfate-rich water into mining areas were to occur, uranium might precipitate prematurely, decreasing recovery rates.

CBM development under Alternative 1 would not be likely to affect the recovery of other mineral resources occurring in the Project Area. Oil and gas have been produced from geologic formations occurring several thousand feet below the coal zone. Salable minerals, primarily clinker, sand, and gravel, are produced from surface deposits. Bentonite, high-calcium limestone, and gypsum occurring in rocks exposed along the uplifted margins of the study, are stratigraphically below the geologic formations that may be affected by CBM development in the PRB. No other locatable mineral deposits are known to exist in the Project Area. Development of existing mineral rights in the Project Area would be based on existing claims, lease terms and agreements; future conflicts would be dealt with on a case-by-case basis.

Alternative 2

Effects on mineral and energy resources likely would be similar to those described under Alternative 1.

Alternative 3

Effects on mineral and energy resources likely would be similar to those described under Alternative 1; however the exclusion of Federal wells and the overall reduced number of CBM wells under Alternative 3 would result in some variations from the effects described under Alternative 1. The magnitude of the effects on mineral and energy resources under Alternative 3 likely would be reduced. Drainage of CBM resources likely would be greater under Alternative 3, as more new drainage situations would be created by the exclusion of Federal wells from projected activities.

Geologic Hazards

Potential effects, such as creating geologic hazards, are not likely to occur. As part of the APD approval process for Federal lease development, BLM, and FS when involved, require consideration of geologic hazards contained in all areas where ground-disturbing activity is proposed. APD conditions of approval would require mitigation of effects.

All facilities located on Federal surface ownership lands would be considered Federal undertakings, subject to Federal guidelines and regulations for environmental protection. Where oil or gas development excludes Federal leases or surface ownership lands, no Federal permits are required to develop these lands, and protection measures for geologic hazards might not be mandated by the landowners or monitored as closely.

Alternative 1

In portions of the Project Area where underground injection would be used as one of the methods of handling the water produced by CBM wells, no excessive build-up of rock pressure or fracturing of rocks that could cause an earthquake to occur would be anticipated during injection activities. Therefore, no earthquakes associated with underground injection would be expected to occur. Use of underground injection to dispose of produced water would occur in accordance with Federal and State regulatory requirements. Injection wells would be authorized only where the injection zone is sufficiently porous and permeable that fluids could enter the rock formation without causing an excessive build-up of pressure or fracturing of rocks.

Anticipated CBM flows could increase the frequency or magnitude of flooding anticipated in the Project Area. Minimization of flood hazards within the Project Area would be dependent upon the use of mitigating measures to ensure adequate control of anticipated surface flows and design of impoundments. Comprehensive water management planning, including development and implementation of best management practices for discharge outfalls and water development structures, would mitigate the effects of anticipated CBM flows. However, when lower than anticipated flood damage occurred during an intense storm near Gillette in May 2000, this event demonstrated that management of existing CBM flows, including construction of many small reservoirs, reduced the severity of flooding in the Project Area in one case.

Surface disturbance could worsen existing landslide hazards in the Project Area, and could cause new landslide hazards. Unless disturbance to existing landslides and areas susceptible to movement, such as steep slopes or unstable soils, is avoided or mitigated during oil or gas development, mass movements likely would increase within the Project Area, causing resource and property damage. Landslides could be activated during oil or gas development activities, however, design of operations incorporating best management practices and mitigation measures that minimize landslide risks would lessen the potential that landslides would increase within the Project Area.

Surface disturbance could cause or worsen the continuing migration of windblown sand deposits occurring along the southeastern and eastern margins of the

PRB, unless disturbed areas are stabilized promptly with vegetative cover. Continuing migration of windblown deposits would contribute to soil loss, if existing soils were blown away with sands. Increased sedimentation in surface drainages also would result from the migration of sand deposits.

CBM development would not be likely to cause noticeable ground subsidence, aquifer compression, or aquifer collapse in the Project Area. Where unconsolidated alluvial aquifers have collapsed in other geographic areas due to dewatering, significant ground subsidence has occurred. However, the Fort Union Formation is a consolidated rock unit and is not as susceptible to aquifer compression or collapse as an unconsolidated unit. Also, based on its estimated storage coefficient, and recognized depth from the surface to the coal zone aquifer where decline in the hydraulic head could occur, the Fort Union Formation could not be dewatered enough to cause noticeable ground subsidence.

Case et al. (2000) describe the formula used to calculate the amount of aquifer compression that occurs when water is withdrawn from an aquifer. The change in aquifer thickness is equal to the storage coefficient times the change in head. The storage coefficient is determined through a pump test and the change in head is observed (or monitored) over time as declines in water level.

The storage coefficient used by Case et al. (2000) for PRB producing coals and underlying sands (1.0×10^{-4}), represents the best estimate available for the storage coefficient applicable to the Fort Union Formation. Since the Big George coal zone occurs between 1,000 and 2,000 feet below the surface in the central portion of the PRB, a theoretical drawdown to the top of the Big George coal zone could be up to 2,000 feet in the central portion of the PRB. Applying the formula described above allows consideration of the largest aquifer compression theoretically possible in the central portion of the PRB. It should be noted that a decline in hydraulic head to the top of the Big George coal zone is not projected in this analysis of the environmental effects under Alternative 1.

Aquifer compression in the central portion of the PRB theoretically could be 2.4 inches, if the hydraulic head in the Fort Union Formation declined to the top of the Big George coal zone, although a decline of this magnitude is not projected under Alternative 1. Since the compressibility of an aquifer decreases with increasing depth, (Edgar and Case 2000), CBM development of deeper coals, such as the Big George zone, likely would result in less actual aquifer compression than is calculated above. In addition, the entire aquifer compression likely would not be transmitted to the surface, resulting in no noticeable ground subsidence even under maximum theoretical drawdown. The effects of aquifer compression under Alternative 1 would be even less, and would not be noticeable.

Gas migration, seepage, and venting are naturally occurring processes where coal beds are extremely close to the surface, and can be enhanced during CBM development activities. Methane migration or seepage could occur within the PRB as CBM development proceeds. Conditions for methane release would depend on site-specific geologic conditions and/or the specific well development conditions that remain after construction. Methane could emerge from water wells near CBM production areas, affecting stock and residential wells. The escape of methane also can result from inadequate well control procedures or faulty well

casing or plugging. Methane would be controlled through BLM mandated APD conditions of approval addressing well control, casing, ventilation, and plugging procedures appropriate to site-specific CBM development plans.

CBM development is not likely to increase the occurrence of underground coal fires in the Project Area. CBM development in the PRB, including development under Alternative 1, is occurring under confined conditions in the coal aquifer, which are not associated with spontaneous fires. The partial removal of water from the coal seam during CBM development depressurizes the coal seam, and reduces hydraulic head, but is not likely to leave the coal seam in a condition where oxygen would replace water in the coal seam and result in spontaneous combustion. The conditions established and maintained in CBM wells during drilling and after well completion in order to meet health and safety requirements and optimize gas production, also create unfavorable conditions for the spontaneous combustion of coal. Wellbore conditions are controlled to ensure airflow out of the well, flushing of fines from the well, and venting of heat at the surface.

Alternative 2

Effects associated with geologic hazards likely would be similar to those described under Alternative 1.

Alternative 3

Under Alternative 3, additional development of Federal leases (other than Federal protective wells in drainage situations) would not be authorized once existing authorizations under the Wyodak CBM Project EIS and the Wyodak Drainage CBM EA have been exhausted. Effects associated with geologic hazards likely would be similar to those described under Alternative 1, although oil or gas development of Fee and State leases under Alternative 3 would involve far fewer Federal undertakings than Alternatives 1 or 2, and less Federal control of CBM development activities in geologic hazard areas.

Soils

Short-term effects associated with construction activities consist of construction of roads, well pads and production facilities, water handling facilities, erection of overhead electric lines, and burial of water and gas pipelines and electric lines. Disturbances related to the burial of pipelines and electric lines would not occur in the long-term as the trenches would be reclaimed upon completion. Because most of the well pad is not needed for production, a majority of the disturbance associated with well pad construction would consist of short-term disturbance.

Long-term effects include the disturbance of soils for roads, reduced well pads and production facilities, water handling facilities, and overhead electric lines. All facilities under long-term effects are necessary for production of CBM gas or water management.

Effects to soils result from the clearing of vegetation, excavation, stockpiling and redistribution of soils during reclamation and construction activities, compaction, and the storage or discharge of produced water. Loss of vegetation would expose

soils and could result in a loss of organic matter in the soil. Excavation for facility pads and roads could cause slope steepening in cut and fill areas, mixing of soil layers, and the breakdown of soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and a loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. Depending on the infiltration rates, storage or discharge of produced water could alter physical and chemical properties of soils. All these effects could alter the soil's resistance to water and wind erosion and response to reclamation.

While the discussions in this section are adequate for a general level of analysis, it is insufficient for use in locating specific well pads, access roads, pipelines, and other associated facilities. Site-specific analysis, typically done during the APD process, would identify particular soil concerns and appropriate mitigation measures. The Buffalo Field Office Coal Bed Methane Well APD and Project Planning Guide (October 2000) provides guidelines for this analysis.

Alternative 1

In all, an estimated 211,992 acres of land, or 2.7 percent of the Project Area, may be affected by CBM development activities in the short term. In contrast, approximately 108,779 acres of land, or 1.4 percent of the Project Area, may be affected in the long term. These disturbances would occur on 23 of the 59 soils series that exist in the Project Area. Only soils that would be disturbed by the alternatives will be discussed in this analysis. Together, these soil series make up approximately 75 percent of the Project Area. Table 4–8 breaks down disturbance by sub-watershed and soil type and Table 4–9 lists the disturbance for each type of hazard.

Wind Erosion Hazard

Wind erosion is a concern with soil series WY124, WY126, WY207, WY209, and WY211 located in central and western Converse County and extending from south of Gillette to the Montana-Wyoming state line in Campbell County (Figure 4–42). These series all have one or more major constituent that is a fine sand or sandy loam which can easily be picked up and spread by wind (Appendix F). Approximately 25,474 acres in the short term and 13,403 acres in the long term would be disturbed on soils with high wind erosion potential. Construction activities where vegetation is removed and the soil is exposed and broken up present the greatest threat to soils with wind erosion potential. These activities include cut and fills associated with pad and roads, trenching for pipeline burial, excavation for large reservoirs, and clearing for LADs. COAs should be followed to control wind erosion. Limiting the removal of vegetation, avoiding construction on steep slopes and erosive areas, revegetation or covering any removed and stockpiled topsoil, surfacing roads and pads, and timely reclamation would minimize both short term and long term effects.

Table 4–8 Disturbance by Sub-watershed and Soil Type

Sub-watershed	Soil Type[1]	Disturbance Alternative 1 Short-term	Alternative 1 Long-term	Alternative 2A Short-term	Alternative 2A Long-term	Alternative 2B Short-term	Alternative 2B Long-term
Antelope	*WY125*	13	12	13	13	13	13
	WY129	10,360	4,287	10,619	4,456	10,511	4,382
	WY130	18,203	7,551	18,659	7,848	18,470	7,718
	WY206	467	217	478	225	473	221
	WY207	307	184	315	191	311	188
	WY208	1,056	441	1,082	458	1,071	451
	WY209	2,200	933	2,255	969	2,232	953
	WY210	783	327	803	340	795	334
	WY211	785	335	804	348	796	342
	WY315	13	12	13	13	13	13
	Total	34,185	14,299	35,043	14,861	34,686	14,616
Clear Creek	*WY048*	1,872	990	2,029	1,142	1,917	1,029
	WY049	7,417	4,085	8,035	4,712	7,595	4,248
	WY060	5	6	6	7	5	7
	WY063	21	26	23	30	21	27
	WY065	4,226	2,287	4,578	2,638	4,327	2,378
	WY066	2,199	1,154	2,383	1,331	2,252	1,199
	WY082	69	36	75	42	70	38
	Total	15,810	8,585	17,127	9,903	16,189	8,926
Crazy Woman Creek	*WY048*	869	404	996	534	950	487
	WY049	4,880	2,326	5,593	3,072	5,334	2,803
	WY050	1,112	510	1,275	673	1,216	614
	WY060	9	10	11	13	10	12
	WY063	5	5	5	7	5	6
	WY065	2,051	943	2,351	1,246	2,242	1,137
	WY066	4	2	5	2	4	2
	WY082	5,104	2,418	5,849	3,192	5,578	2,913
	WY087	5	5	5	7	5	6
	Total	14,039	6,624	16,089	8,746	15,343	7,981
Dry Fork Cheyenne	WY203	4	4	4	4	4	4
	WY204	33	30	34	30	34	30
	WY205	4	4	4	4	4	4
	WY206	21	19	21	19	21	19
	WY207	21	19	21	19	21	19
	WY208	8	7	8	8	8	8
	WY209	54	49	55	50	54	49
	WY210	41	37	42	38	42	38
	WY211	17	15	17	15	17	15
	Total	203	183	207	187	205	186
Lightning Creek	WY204	37	34	38	34	38	34
	WY209	112	101	114	103	113	102
	WY210	29	26	30	27	29	27
	WY211	25	22	25	23	25	23
	Total	203	183	207	187	205	186
Little Bighorn	WY057	21	19	21	19	21	19
	Total	21	19	21	19	21	19
Little Missouri	WY002	17	15	17	15	17	15
	WY050	21	19	21	19	21	19
	WY053	352	317	358	324	356	322
	Total	389	351	396	358	394	357
Little Powder	WY002	35	34	37	37	36	35
	WY042	9	8	9	9	9	9
	WY043	13	13	14	14	14	13
	WY044	9	8	9	9	9	9
	WY045	75	71	79	78	77	75
	WY046	61	59	65	64	63	61
	WY047	413	394	435	430	424	412
	WY050	4,200	2,681	4,430	2,923	4,318	2,804
	WY053	2,345	2,237	2,473	2,440	2,410	2,341

Table 4–8 Disturbance by Sub-watershed and Soil Type

Sub-watershed	Soil Type[1]	Disturbance Alternative 1 Short-term	Alternative 1 Long-term	Alternative 2A Short-term	Alternative 2A Long-term	Alternative 2B Short-term	Alternative 2B Long-term
		1,623	885	1,711	965	1,668	926
	WY125	5,185	2,190	5,468	2,388	5,331	2,291
	WY126	5,770	2,454	6,086	2,676	5,933	2,567
	WY127	2,326	1,704	2,453	1,858	2,391	1,782
	Total	22,063	12,737	23,268	13,891	22,683	13,325
Middle Fork Powder	*WY048*	8	7	8	8	8	8
	WY059	37	34	38	34	38	34
	WY081	8	7	8	8	8	8
	WY084	12	11	13	11	13	11
	WY085	4	4	4	4	4	4
	WY086	8	7	8	8	8	8
	WY088	21	19	21	19	21	19
	Total	99	90	101	91	101	91
Middle North Platte Casper	WY204	8	7	8	8	8	8
	WY205	50	45	51	46	50	46
	WY207	21	19	21	19	21	19
	WY208	33	30	34	30	34	30
	WY209	37	34	38	34	38	34
	WY321	8	7	8	8	8	8
	Total	157	142	160	145	159	144
Middle Powder	WY046	136	143	149	169	143	157
	WY048	12	8	14	10	13	9
	WY049	991	526	1,084	620	1,040	576
	WY050	2,604	1,261	2,847	1,486	2,734	1,380
	WY124	1,312	733	1,434	863	1,377	802
	Total	5,055	2,672	5,527	3,148	5,307	2,924
North Fork Powder	WY059	4	4	4	4	4	4
	Total	4	4	4	4	4	4
Salt Creek	*WY050*	521	215	542	231	539	230
	WY082	339	129	352	138	350	137
	WY085	9	8	9	9	9	9
	WY086	51	48	53	51	53	51
	WY208	9	8	9	9	9	9
	WY211	13	12	13	13	13	13
	WY315	4	4	4	4	4	4
	WY317	13	12	13	13	13	13
	Total	958	435	996	467	990	465
South Fork Powder	WY084	12	11	13	11	13	11
	Total	12	11	13	11	13	11
Upper Belle Fourche	*WY004*	562	322	572	328	563	320
	WY053	357	401	364	409	358	399
	WY115	10	11	10	11	10	11
	WY126	8,208	4,654	8,355	4,748	8,223	4,630
	WY127	1,420	1,194	1,445	1,218	1,422	1,188
	WY128	531	287	541	293	532	285
	WY129	3,441	1,746	3,503	1,781	3,447	1,737
	WY130	13,434	6,913	13,674	7,054	13,458	6,878
	Total	27,965	15,528	28,464	15,843	28,014	15,449
Upper Cheyenne	*WY004*	14	15	15	16	15	16
	WY115	19	20	20	22	19	21
	WY127	19	20	20	22	19	21
	WY129	2,628	1,343	2,748	1,449	2,684	1,390
	WY130	148	82	154	89	151	85
	WY206	34	33	36	36	35	34
	Total	2,862	1,515	2,993	1,634	2,923	1,568
Upper Powder River	*WY048*	3,317	1,649	3,812	2,165	3,661	2,012
	WY049	4,601	2,236	5,288	2,935	5,078	2,727
	WY050	27,222	13,490	31,286	17,710	30,046	16,454

Table 4–8 Disturbance by Sub-watershed and Soil Type

Sub-watershed	Soil Type[1]	Disturbance Alternative 1 Short-term	Alternative 1 Long-term	Alternative 2A Short-term	Alternative 2A Long-term	Alternative 2B Short-term	Alternative 2B Long-term
	WY051	684	327	786	429	755	398
	WY082	7,515	3,820	8,637	5,015	8,294	4,659
	WY124	3,350	1,660	3,850	2,179	3,697	2,024
	WY125	9,546	4,714	10,972	6,189	10,537	5,750
	WY126	889	429	1,022	564	981	524
	WY128	13,269	6,584	15,250	8,644	14,646	8,031
	WY130	1,464	742	1,683	975	1,616	905
	WY209	19	21	22	28	21	26
	WY315	5	5	5	7	5	6
	Total	71,880	35,678	82,612	46,839	79,338	43,517
Upper Tongue River	*WY049*	6,663	3,449	7,095	3,861	6,745	3,504
	WY051	374	194	398	217	378	197
	WY055	2,412	1,279	2,569	1,432	2,442	1,299
	WY056	10	12	11	13	10	12
	WY057	10	12	11	13	10	12
	WY060	5	6	5	7	5	6
	WY063	5	6	5	7	5	6
	WY064	2,189	1,141	2,331	1,277	2,216	1,159
	WY065	2,036	1,049	2,168	1,174	2,061	1,065
	WY066	2,382	2,597	3,067	3,359	2,412	2,638
	Total	16,087	9,744	17,658	11,359	16,284	9,898
Total in Project Area		211,992	108,799	230,886	127,693	222,860	119,667

Note:
1. Italics designated soil types with severe hazards.

Slope Hazards

While the Project Area contains a large range of slopes (Figure 3–6), all wells, roads and production facilities have been located on gentle to moderate slopes to minimize construction costs and erosion hazards. This would reduce potential for water and wind erosion by reducing steep slopes and surface disturbance associated with large cuts and fills.

The slope ranges and figures used for this analysis are very general and some wells may be located on more severe slopes than currently shown on Figure 3–6. Specific facility locations and roadways should be assessed for slope and any related erosion hazards and soil instabilities. Steep slopes should be avoided where possible, especially on soils susceptible to erosion. On gentle to moderate slopes, soil loss due to wind and water erosion could be effectively controlled by following the COAs.

Water Erosion Hazards

Water erosion is a concern with soil series WY049, WY050, WY051, WY065, WY066, WY206, WY208, WY209, WY210 and WY211 located in eastern Sheridan County, northern and western Campbell County, throughout Converse County and in Johnson County along the I-25 corridor to Buffalo, and along the Powder River (Figure 4–42). These series all have one or more major constituents that have low permeability and high K-factors, making them susceptible to water erosion (Appendix F). Approximately 76,691 acres in the short term and 38,452 acres in the long term would be disturbed on soils with a high water erosion potential.

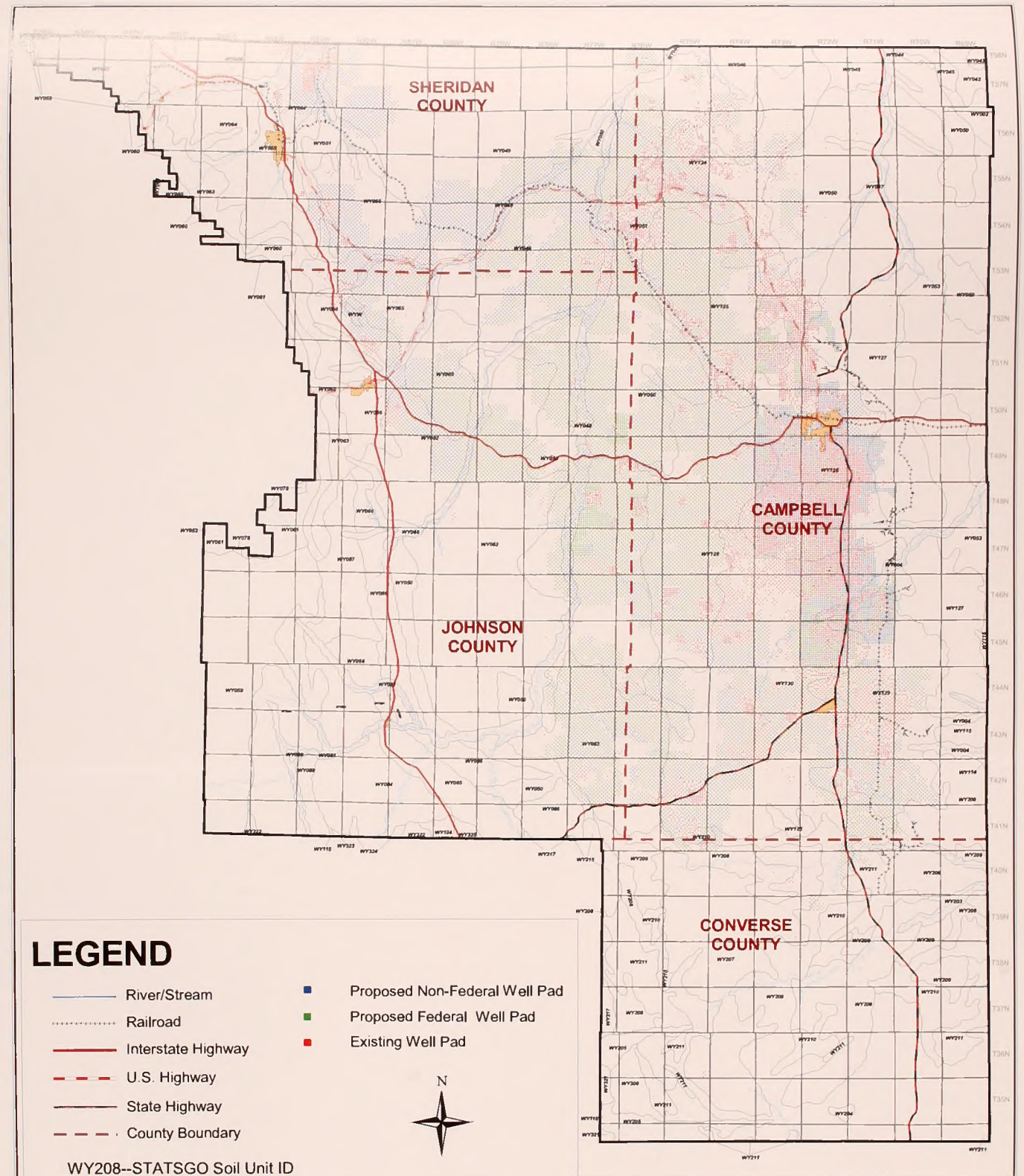
Table 4–9 Disturbance by Sub-watershed and Hazard

		Disturbance					
		Alternative 1		Alternative 2A		Alternative 2B	
Sub-watershed	Hazard	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Antelope	Wind Erosion	3,292	1,452	3,374	1,508	3,339	1,483
	Water Erosion	5,291	2,253	5,422	2,340	5,367	2,301
	Compaction	30,402	12,606	31,163	13,102	30,847	12,885
	Salinity	None	None	None	None	None	None
	Poor Revegetation	5611	2449	5750	2544	5691	2502
	Prime Agricultural	22,549	9,436	23,114	9,806	22,879	9,644
Clear Creek	Wind Erosion	None	None	None	None	None	None
	Water Erosion	13,842	7,526	14,996	8,681	14,174	7,825
	Compaction	7,486	4,121	8,110	4,754	7,665	4,286
	Salinity	None	None	None	None	None	None
Clear Creek	Poor Revegetation	13,911	7,562	15,071	8,723	14,244	7,863
	Prime Agricultural	15,714	8,516	17,025	9,823	16,091	8,854
Crazy Woman Creek	Wind Erosion	None	None	None	None	None	None
	Water Erosion	3,167	1,455	3,631	1,921	3,462	1,753
	Compaction	9,984	4,744	11,442	6,264	10,912	5,716
	Salinity	None	None	None	None	None	None
	Poor Revegetation	12,039	5,689	13,798	7,512	13,158	6,855
	Prime Agricultural	7,804	3,675	8,945	4,854	8,530	4,429
Dry Fork Cheyenne	Wind Erosion	92	83	93	84	92	83
	Water Erosion	141	127	143	130	142	129
	Compaction	49	44	50	46	50	46
	Salinity	None	None	None	None	None	None
	Poor Revegetation	162	146	164	149	163	148
	Prime Agricultural	124	112	126	115	125	114
Lightning Creek	Wind Erosion	137	123	139	126	138	125
	Water Erosion	166	149	169	153	167	152
	Compaction	29	26	30	27	29	27
	Salinity	None	None	None	None	None	None
	Poor Revegetation	166	149	169	153	167	152
	Prime Agricultural	141	127	144	130	142	129
Little Bighorn	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards
Little Missouri	Wind Erosion	None	None	None	None	None	None
	Water Erosion	21	19	21	19	21	19
	Compaction	None	None	None	None	None	None
	Salinity	None	None	None	None	None	None
	Poor Revegetation	21	19	21	19	21	19
	Prime Agricultural	None	None	None	None	None	None
Little Powder	Wind Erosion	7,393	3,339	7,797	3,641	7,601	3,493
Little Powder	Water Erosion	4,200	2,681	4,430	2,923	4,318	2,804
	Compaction	1,623	885	1,711	965	1,668	926
	Salinity	None	None	None	None	None	None
	Poor Revegetation	7,511	3,894	7,921	4,246	7,722	4,073
	Prime Agricultural	6,808	3,075	7,179	3,353	6,999	3,217
Middle Fork Powder	Wind Erosion	None	None	None	None	None	None
	Water Erosion	None	None	None	None	None	None
	Compaction	None	None	None	None	None	None
	Salinity	None	None	None	None	None	None
	Poor Revegetation	None	None	None	None	None	None
	Prime Agricultural	8	7	8	8	8	8
Middle North Platte Casper	Wind Erosion	58	53	59	53	59	53
	Water Erosion	70	64	72	64	72	64
	Compaction	33	30	34	30	34	30
	Salinity	None	None	None	None	None	None
	Poor Revegetation	91	83	93	83	93	83
	Prime Agricultural	91	83	93	83	93	83
Middle Powder	Wind Erosion	1,312	733	1,434	863	1,377	802
	Water Erosion	6,219	3,253	6,799	3,832	6,528	3,560
	Compaction	2,303	1,259	2,518	1,483	2,417	1,378
	Salinity	None	None	None	None	None	None
	Poor Revegetation	3,595	1,787	3,931	2,106	3,774	1,956
	Prime Agricultural	2,315	1,267	2,532	1,493	2,430	1,387

Table 4–9 Disturbance by Sub-watershed and Hazard

		Disturbance					
		Alternative 1		Alternative 2A		Alternative 2B	
Sub-watershed	Hazard	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
North Fork Powder	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards
Salt Creek	Wind Erosion	13	12	13	13	13	13
	Water Erosion	543	235	564	253	561	252
	Compaction	348	137	361	147	359	146
	Salinity	None	None	None	None	None	None
	Poor Revegetation	882	364	916	391	911	389
Salt Creek	Prime Agricultural	9	8	9	9	9	9
South Fork Powder	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards
Upper Belle Fourche	Wind Erosion	8,208	4,654	8,355	4,748	8,223	4,630
	Water Erosion	None	None	None	None	None	None
	Compaction	17,406	8,946	17,718	9,128	17,437	8,900
	Salinity	562	322	572	328	563	320
	Poor Revegetation	1,420	1,194	1,445	1,218	1,422	1,188
	Prime Agricultural	22,204	11,889	22,601	12,130	22,244	11,828
Upper Cheyenne	Wind Erosion	None	None	None	None	None	None
	Water Erosion	34	33	36	36	35	34
	Compaction	2,790	1,440	2,917	1,554	2,850	1,491
	Salinity	14	15	15	16	15	16
	Poor Revegetation	53	53	56	58	54	55
	Prime Agricultural	162	97	169	105	166	101
Upper Powder River	Wind Erosion	19	21	22	28	21	26
	Water Erosion	32,526	16,074	37,382	21,102	35,900	19,605
	Compaction	30,883	15,369	35,494	20,177	34,086	18,744
	Salinity	None	None	None	None	None	None
	Poor Revegetation	48,903	24,281	56,205	31,877	53,976	29,616
	Prime Agricultural	14,324	7,064	16,463	9,275	15,809	8,616
Upper Tongue River	Wind Erosion	None	None	None	None	None	None
	Water Erosion	11,455	7,289	12,728	8,611	11,596	7,404
	Compaction	9,226	4,784	9,824	5,355	9,339	4,860
	Salinity	None	None	None	None	None	None
	Poor Revegetation	11,081	7,095	12,330	8,394	11,218	7,207
	Prime Agricultural	16,056	9,709	17,628	11,320	16,254	9,862

Construction and operation activities could potentially increase soil loss due to water erosion. Removal of vegetation for any activity exposes soils to increased water erosion. Excavation associated with construction of pads, roads and reservoirs could steepen slopes and cause the breakdown of soil aggregates, increasing runoff and gully formation. Pipeline trenches could change erosion patterns if soils settle in the backfilled trench after reclamation and form gullies. Compaction of the soils in pads, roads and reservoirs could decrease infiltration, promoting high runoff. Any water handling method which would release produced water to the surrounding area could increase water erosion. However, increased water availability would also increase vegetation, partially mitigating any erosive effects.



LEGEND

- River/Stream
- Railroad
- Interstate Highway
- U.S. Highway
- State Highway
- County Boundary

WY208--STATSGO Soil Unit ID

- Proposed Non-Federal Well Pad
- Proposed Federal Well Pad
- Existing Well Pad

N

Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 4-42 SOILS AND EXISTING AND PROPOSED CBM WELLS	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_v1\data\maps.apr Layout–Soils Slope
	DRAWN BY: MSH

Existing CBM Well location data provided by the Wyoming Oil and Gas Commission. Thunder Basin National Grassland data provided by the US Forest Service. All other data provided by the Bureau of Land Management–Buffalo Field Office and Casper Field Office.

Transverse Mercator Projection 1927 North American Datum Zone 13

The Revised Universal Soil Loss Equation (RUSLE) was used to compute soil loss due to raindrop splash and runoff (USDA 1997). Estimates were calculated using three conditions: (1) undisturbed (existing rangeland condition); (2) construction (during construction and prior to reclamation); and (3) reclaimed (one year after reclamation, assuming 40 percent vegetative cover). The assumption of 40 percent vegetative cover one year after reclamation was based on information used for soil loss calculations on CBM projects in the region (BLM 1999a). In order to simplify calculations, all factors, except for K, were assumed to be consistent throughout the Project Area, even though soil loss would be variable throughout the Project Area. The highest and lowest K factors for the 23 disturbed soils were used to estimate the maximum and minimum soil loss in the Project Area. For the undisturbed condition, soil loss estimates ranged from 0.1 to 0.6 tons/acre/year. During construction, soil loss estimates ranged from 3.4 to 18.7 tons/acre/year. One year following reclamation, soil loss estimates ranged from 0.5 to 2.6 tons/acre/year. These calculations were based on slopes 400 feet long having a slope gradient of three percent on undisturbed ground.

RUSLE calculations were done to estimate soil loss increases on disturbed land due to overland flow. Water erosion in drainages downstream from CBM activities due to runoff the release of produced water could increase but this erosion cannot be accurately predicted using RUSLE. A more detailed description of erosive effects to drainages is contained in the Surface Drainages section of the Surface Water section.

Soil loss would likely increase substantially in the short-term following disturbance until reclamation measures became effective in controlling runoff. In addition, soil loss during construction would exceed acceptable levels for all of the disturbed soil series in the Project Area (NRCS Soil Surveys). These potential effects point to a need for adoption of COAs during the life of the project.

Soil loss can be reduced substantially by avoiding highly erosive areas like badlands, steep-walled drainages, blowout areas and other areas subject to active headward erosion (BLM 1999c). Locating roads and pads in areas where cuts and fills would not be required, surfacing of roads and pads, installing drainage controls, and reseeding and installing water bars across reclaimed areas would also aid in reducing soil loss. Pipeline trenches should be mounded when backfilled to prevent soil settling and forming gullies. COAs such as these have resulted in very little accelerated erosion and a high level of reclamation success on the Marquiss Project, located south of Gillette (BLM 1999a).

Sedimentation

Sedimentation in streams and rivers in the Project Area is an important result of soil loss, but can not be adequately estimated simply by calculating soil loss. The movement of eroded soil materials to drainages can be blocked or facilitated by relief, climate, vegetation, and bedrock geology. Due to these characteristics, there is a large difference between soil loss and sediment flow. Sedimentation would be variable throughout the Project Area, but in general only ten percent of soil loss would remain in the water flow at the point of exit from the subwatersheds (Blatt et al. 1972). The remaining 90 percent would never reach flowing water or be deposited in the streambeds of the watershed. Sedimentation

deposition could alter water quality and the fluvial characteristics of drainages in the Project Area and point to a need for COAs associated with water erosion to control sedimentation. Water in the drainages should be monitored for high levels of TDS as well. The Surface Drainages section also contains information on the effects of sedimentation on drainages.

Compaction/Shrink-Swell Potential

Compaction is a concern with soil series WY004, WY049, WY051, WY064, WY082, WY124, WY128, WY129, WY130, WY208, and WY210 located throughout Campbell and Converse counties and eastern Sheridan and Johnson counties (Figure 4–42). These series all have one or more major constituents that include very compactable clay loams (Appendix F). Approximately 113,998 acres in the short term and 55,829 acres in the long term would be disturbed on compactible soil. Clay grains are extremely small and can be forced so closely together that few pore spaces remain. Thus, most air and water is pushed out of the soil and plants roots would be unable to penetrate the soil. Due to the absence of air and water and the difficulty of root growth, reclamation of a tightly compacted clay soil can be difficult. Compacted soils also have low permeability, and runoff is high, adding to water erosion.

Activity on well pads, production facilities and roads, and storage of water in reservoirs have the potential to compact soils. COAs would minimize both short and long-term effects. Pad and road construction, and traffic on highly compactable soils should be minimized wherever possible, and soils should be loosened prior to reseeding during reclamation. COAs to reduce water erosion should be employed on compactible soils due to the high runoff potential.

Salinity

Only one soil series, WY004 is listed by the NRCS's Soil Surveys as having high salinity (Appendix F). Approximately 558 acres in the short term and 312 acres in the long term would be disturbed on this soil. This statement is misleading, as the salinity of soils like most chemical characteristics is highly variable and can change drastically over a few feet. Any soil in the Project Area can be saline, depending on the quality of nearby surface water, plant species, and drainage characteristics. Decisions on the locations of water disposal facilities that could affect soil salinity and other chemical levels should be based on these parameters.

Due to the variable nature of produced water and differing characteristics of soils in the Project Area, water handling options could have significant effects on soils. Five water handling options are included under Alternative 1: injection; surface discharge (including infiltration and irrigation); infiltration reservoirs; containment reservoirs; and LAD. Injection would affect soils in the Project Area the least, having effects similar to CBM well construction and production activities. After injection, containment would introduce the least amount of produced water to the surrounding soils. These reservoirs should be lined or compacted to prevent produced water from inundating the soils below. Due to the large size of the reservoirs, compaction is the most reasonable method to reduce infiltration. Locating containment reservoirs on compactable soils where infiltration would be ten percent or less would also help to reduce effects on soils. Of course, soils below these reservoirs would be affected by this compaction and infiltration.

COAs should be followed during construction of reservoirs to prevent erosion. Even with COAs, reclamation would be very difficult based on sheer size of the area, amount of soil moved, the concentrated compaction below the reservoir, and the material remaining after the produced water has evaporated.

Surface discharge (including infiltration and irrigation), infiltration reservoirs and LAD would introduce the most produced water to the surrounding soils. Due to the deleterious effect of high SAR water on soil productivity and reclamation potential, care should be taken that produced water is not discharged near or applied to highly saline soils. The sodium capacity of each soil should be known, application should be halted when that capacity is reached, and the soil should be reclaimed. Halting the application of produced water to reclaim the soil would be much more difficult in the reservoirs then under LAD or surface discharge. General Guidance for Land Application of CBM Produced Water should be followed to mitigate effects to soils (Appendix F).

Suitability for irrigation is dependent upon interaction of soil types, SAR values, salinity values, and crops grown. The decision to use produced water for irrigation should be made on a site-by-site basis.

Undesired consequences could also occur should produced water from CBM wells be discharged at points within closed basins. Water discharged within a closed basin would drain to the low point of the basin or playa. The sustained release of produced water from CBM wells could accumulate in closed basins as water is evaporated leaving its dissolved minerals, like sodium, behind as solids. Also, regardless of the salinity levels in the inflows and playa soils, the long-term ponding of playa bottoms would alter the normally dry soil/playa bottom conditions and would result in changes in soil conditions (BLM 1999c).

The development of saline and wet soil conditions could be minimized by avoiding discharge in or upstream from areas where water could become concentrated in the soils or where soils are already saline. Even with these practices, water quality and soils in the Project Area should be monitored for high salinity and SAR levels.

Effects similar to those described in closed basins could occur in infiltration reservoirs. Avoiding constructing infiltration reservoirs on highly saline areas would reduce the effects to soils. Locating reservoirs on area where water could easily move through the soils, such as soils with low potential for compaction, high permeability and porous bedrock would reduce the potential for saturation of the soil.

Reclamation of saline soils can be difficult and no method that works in all situations has yet been found. Possible methods include raising salt-resistant crops, and repeatedly flooding the affected area with low SAR water. The success of these methods would depend on soils types, salinity values, and drainage characteristics of the area.

Poor Revegetation Potential

Poor revegetation potential is a concern with soil series WY049, WY050, WY065, WY066, WY082, WY125, WY127, WY206, WY207, WY208, WY209, WY210, and WY211 located in northern Campbell County, throughout Converse County, east of Interstate-25 in Sheridan County, and in Johnson County along the Interstate-25 corridor to Buffalo, and along the Powder River (Figure 4–42). These series all have capability classes indicating that the soil would respond poorly to reclamation (Appendix F). About 108,292 acres in the long term and 55,139 acres in the short term would be disturbed on soils with poor revegetation potential.

All previously discussed hazards have a potential effect on revegetation potential. Thus, COAs associated with all other categories in this section would aid in reclamation. Mixing of soil materials during excavation or compaction, especially in soil series listed above, where one or two dominant soils have poor revegetation potential, could have an effect on reclamation and future productivity. The COAs do not mention avoiding soil mixing, but this mitigation measure is recommended by numerous soil surveys in the area. WY206 and WY211 should be avoided in areas where the soil is shallow or on steep slopes as all three major soil types in these series have poor revegetation potential.

Prime Agricultural Soils

Prime agricultural soils are found in soil series WY004, WY048, WY049, WY051, WY055, WY064, WY065, WY066, WY124, WY126, WY130, WY207, WY208, WY209, and WY210 located in central Campbell County, throughout Converse and Sheridan Counties, in Johnson County along the Interstate-25 corridor, and along the Powder River (Figure 4–42). These series all have one or more major constituents identified by the Wyoming state office of the Natural Resources Conservation Service as Prime Agricultural Soils (Appendix F). About 106,068 acres in the short term and 52,414 acres in the long term would be disturbed on Prime Agricultural soils.

All previously discussed hazards have a potential effect on soil productivity. Thus, COAs associated with all other categories in this section would aid in reclamation. Mixing of soils that are not prime agricultural soils with prime agricultural soils during excavation or compaction could have an effect on reclamation and future productivity.

Alternative 2

Alternative 2A

Under this alternative, 230,886 total acres of disturbance would occur in the short term and 127,693 acres in the long term. This is an increase in area of about 18,894 acres from Alternative 1, which can be entirely attributed to a change in water handling methods. Table 4–8 and Table 4–9 show disturbances for each soil and hazard type under this alternative.

Alternative 2A emphasizes the use of infiltration impoundments to dispose of CBM produced water. Surface discharge (and all associated treatments) would be decreased and LAD and containment reservoirs would be increased. The increase in disturbed acreage would correspond to not only a rise in soil loss, but a change in the type of disturbance as well.

Per acre, reservoirs require much more construction than surface discharge due to the amount of excavation. Reservoirs also cause much deeper soil disturbance, increasing the chance for mixing of soils layers. Based on the amount of excavation and the depth of disturbance, construction of reservoirs would lead to greater stockpiles of soils, increasing the chance for wind and water erosion. A greater number of reservoirs would also increase compaction of the soils due to construction and the weight of the water. Because water discharge to natural drainages would have a much higher infiltration rate than the infiltration and containment reservoirs, actual infiltration of produced water would be decreased under Alternative 2A. Effects to soils downstream from Project Area would probably be reduced under a reduction in surface discharge. Increased LAD would increase the amount of infiltration, but this increase would be offset by decrease in surface discharge. In all, Alternative 2A would reduce surface discharge and infiltration, but would increase the potential for wind and water erosion, soil mixing, and compaction.

Alternative 2B

Under this alternative, 222,860 total acres of disturbance would occur in the short term and 119,667 acres in the long term. This is a decrease in area by 8,026 acres from Alternative 2A, and an increase in area of 10,868 acres from Alternative 1, which can be entirely attributed to a change in water handling methods. Table 4–8 and Table 4–9 show disturbances for each soil and hazard type under this alternative.

The decrease in total disturbed acreage from Alternative 2A is due to the increase in surface discharge (and all associated treatments) and the decrease in infiltration and containment impoundments. Like Alternative 2A, Alternative 2B employs greater infiltration impoundments and LAD with less surface discharge than Alternative 1.

Differences in disturbance from Alternative 1 be would similar to those described in Alternative 2A, except on a smaller scale. Due to the increase in surface discharge and decrease in containment and infiltration reservoirs, infiltration would increase, but the potential for wind and water erosion, soil mixing, and compaction would decrease from Alternative 2A to Alternative 2B.

Alternative 3

The No Action Alternative would not authorize additional natural gas development of federal leases within the Project Area. No wells on federal minerals would be drilled, but facilities associated with fee and state wells could be built on federal surface. Wells on private and state leases would probably be drilled. Under this alternative, 90,807 total acres of disturbance would occur in the short term and 45,057 in the long term. This would correspond to a decrease in distur-

bance and soil loss. Water handling methods would be proportionate to Alternative 1.

Cumulative Effects

Alternative 1

By the end of 2001, approximately 12,077 CBM wells would have been drilled in the Project Area (Figure 4–42). Assuming one third of these wells would still be under construction, these wells and their associated facilities would disturb an estimated 12,372 acres in the short term and 14,936 acres in the long term. As much as 17,600 acres may be affected by future non-CBM well development in the long run and 14,432 acres in the short term.

Due to the widespread nature of CBM development, concentrated impacts on soils are not likely, except at reservoirs, LAD sites, and pipeline routes. Other resources in the Project Area could be affected by the changes in soils as well. The large amounts of disturbed and stockpiled soils at reservoirs and LAD sites could affect air quality in the area due to wind erosion. Additional wildlife and cattle usage around reservoirs would further disturb soils through increased traffic and loss of vegetation cover. If trenches were allowed to gully, long pipelines could change drainage patterns in the sub-watersheds. Sedimentation from water erosion could change water quality and fluvial characteristics of streams and rivers in the sub-watersheds of the Project Area. Since disturbed soils with a conductivity of 16 mmhos/cm could release as much as 0.8 tons/acre/year of sodium, SAR of water in the sub-watersheds could be altered by saline soils (BLM 1999). Soils in floodplains and streambeds may also be affected by high SAR and TDS produced water. Methane migration could affect soils by driving oxygen out and producing toxic levels of sulfur, both of which could reduce the productivity in the soil.

In addition to oil and gas activities, uranium, coal, sand, gravel and scoria mining occur within the Project Area. In 20 years, the long-term surface disturbances associated with reasonably foreseeable mineral and energy resource projects may be 165,000 acres or about two percent of the Project Area. Construction activities, such as excavation, compaction, and soil mixing, related to mining would affect soils in much the same way as activities related to CBM activities.

Due to the potential effects on prime agricultural soils and water quality in the project area, impacts to agriculture could occur. CBM facilities should be located with agricultural concerns in mind, and TDS and SAR should be monitored, especially in water used for irrigation, livestock, and human consumption.

Disturbance related to urban and residential acres and recreational activities may increase due to increased CBM activity. Recreational activities, like hunting and off-roading, could increase due to the proliferation of roads from CBM development. While urban and residential development would likely follow COAs for mitigation of effects to soils, recreationists may not. Traffic on CBM roads should be monitored to insure that unnecessary impacts to soils do not occur.

Alternative 2A

The cumulative impacts of Alternative 2A are not expected to vary from those described for Alternative 1.

Alternative 2B

The cumulative impacts of Alternative 2B are not expected to vary from those described for Alternative 1.

Alternative 3

Due to the decreased amount of CBM activity under Alternative 3, all cumulative impacts described for Alternative 1 are expected to decrease, except those related to mineral and energy resource projects.

Air Quality and Climate

No significant, adverse impacts to climate are anticipated from implementation of any development alternative. Potential impacts to air quality were analyzed as described below.

Issues, Impact Types, and Criteria

Fugitive dust and exhaust from construction activities, along with air pollutants emitted during operation (i.e., well operations, injection well and pipeline compressor engines, etc.), are potential causes of unacceptable decreases in air quality. These issues are more likely to generate public concern where natural gas development activities occur near residential areas. The Crow Tribal Council and the Federal Land Managers (FLMs) have expressed concerns regarding potential visibility and atmospheric deposition (acid rain) impacts within distant downwind PSD Class I and PSD Class II areas in Wyoming, Montana, southeastern North Dakota, eastern South Dakota, and northwestern Nebraska.

Potential air quality impacts from potential development were analyzed and reported in the sections on Alternative 1 (Proposed Action) and Cumulative Impacts. This analysis was prepared solely under the requirements of NEPA to assess and disclose reasonably foreseeable impacts to both the public and the Bureau decision maker before a Record of Decision is issued. Due to the preliminary nature of this NEPA analysis, it should be considered a "reasonable, but conservative" upper estimate of predicted impacts. Actual impacts at the time of development (subject to air pollutant emission source permitting) are likely to be less.

The air quality impact assessment was based on the best available engineering data and assumptions, meteorology data, and dispersion modeling procedures, as well as professional and scientific judgment. However, where specific data or procedures were not available, "reasonable, but conservative" assumptions were incorporated. For example, the Alternative 1 air quality impact assessment assumed that all CBM wells would go into production (no dry holes), then operate

at full production levels (no shut-ins) for about seven years, with an overall 20-year life of project (LOP).

Potential direct, indirect and cumulative air quality impacts were analyzed to predict maximum potential near-field ambient air pollutant concentrations and potential hazardous air pollutant (HAP) impacts, as well as to determine maximum far-field ambient air pollutant concentrations, visibility and atmospheric deposition (acid rain) impacts.

Air pollution impacts are limited by state, tribal and Federal regulations, standards, and implementation plans established under the Clean Air Act and administered by the applicable air quality regulatory agency (including the Wyoming Department of Environmental Quality - Air Quality Division (WDEQ-AQD) or the EPA). Although not applicable to the development alternatives, the Departments of Environmental Quality for Montana, South Dakota, and Nebraska have similar jurisdiction over potential air pollutant emission sources in their respective States, which can have a cumulative impact with WDEQ-AQD approved sources. Air quality regulations require proposed new, or modified existing, air pollutant emission sources (including gas compression facilities) undergo a permitting review before their construction can begin. Therefore, the applicable air quality regulatory agencies have the primary authority and responsibility to review permit applications and to require emission permits, fees and control devices, prior to construction and/or operation. The U.S. Congress (through the Clean Air Act Section 116) also authorized local, state and tribal air quality regulatory agencies to establish air pollution control requirements more (but not less) stringent than Federal requirements. Additional site-specific air quality analysis would be performed, and additional emission control measures (including a BACT analysis and determination) may be required by the applicable air quality regulatory agencies to ensure protection of air quality resources.

In addition, under FLPMA and the Clean Air Act, BLM cannot authorize any activity that does not conform to all applicable local, state, tribal and Federal air quality laws, statues, regulations, standards, and implementation plans. An extensive air quality impact assessment technical support document was prepared to analyze potential impacts from the development alternatives, as well as other reasonably foreseeable emission sources, and is available for review (Argonne 2001).

The significance criteria for potential air quality impacts include state, tribal and federally enforced legal requirements to ensure air pollutant concentrations will remain within specific allowable levels. These requirements include the National and Wyoming Ambient Air Quality Standards which set maximum limits for several air pollutants, and PSD increments which limit the incremental increase of certain air pollutants (including NO_2, PM_{10}, SO_2) above legally defined baseline concentration levels. These legal limits are presented in Table 3-13.

Where legal limits have not been established, the BLM uses the best available scientific information to identify thresholds of significant adverse impacts. Thresholds have been identified for HAP exposure, incremental cancer risks, a "just noticeable change" in potential visibility impacts, and potential atmospheric

deposition impacts to sensitive lake water chemistry. Specific threshold levels are described under Alternative 1 (Proposed Action) and under Cumulative Impacts.

Impacts Common to All Alternatives

Air quality impacts would occur during construction (due to potential surface disturbance by earth-moving equipment, vehicle traffic fugitive dust, well testing, and drilling rig and vehicle engine exhaust) and production (including non-CBM well production equipment, booster and reciprocating pipeline compression engine exhausts). The amount of air pollutant emissions during construction would be controlled by watering disturbed soils, and by air pollutant emission limitations imposed by applicable air quality regulatory agencies. Actual air quality impacts depend on the amount, duration, location and emission characteristics of potential emissions sources, as well as meteorological conditions (wind speed and direction, precipitation, relative humidity, etc.).

Alternative 1

Significant air quality impacts would not occur under this Alternative. No violations of applicable state, tribal or Federal air quality regulations or standards are expected to occur as a result of direct, indirect, or cumulative CBM and non-CBM development-related air pollutant emissions (including construction and operation).

Air pollutant dispersion modeling was performed to quantify potential "reasonable, but conservative" PM_{10} and SO_2 impacts during construction based on the individual pollutant's period of maximum potential emissions. The EPA CALPUFF dispersion model was used with meteorological data generated by the MM4 (mesoscale model) and CALMET models. These meteorology data were combined with air pollutant emission values to predict maximum potential concentrations in the vicinity of assumed well and compressor engine emission sources for comparison with applicable air quality standards and PSD Class II increments (Argonne 2001).

Construction emissions would occur during potential road and well pad construction, well drilling, and well completion testing. During well completion testing, natural gas may be vented. Since the burned natural gas is "sweet" (does not contain sulfur compounds), no objectionable odors are likely to occur.

Maximum potential near-field particulate matter emissions from traffic on unpaved roads and during well pad construction were used to predict the maximum 24-hour and annual average PM_{10} concentrations. Maximum air pollutant emissions from each well would be temporary (i.e., occurring during a short construction period) and would occur in isolation, without significantly interacting with adjacent well locations. Particulate matter emissions from well pad and resource road construction would be minimized by application of water. The control efficiency of the dust suppression was computed at 50 percent during construction.

The maximum potential particulate matter concentrations at least 650 feet (200 m) from road and 0.5 miles (805 m) from well emission sources (including

representative background values) would be nearly 55 $\mu g/m^3$ (24-hour PM_{10}), well below the 24-hour PM_{10} NAAQS of 150 $\mu g/m^3$. In addition, predicted particulate matter concentrations would decrease rapidly beyond 200 m from the emission source. Since these PM_{10} construction emissions would be temporary, PSD increments are not applicable.

The predicted maximum 24-hour concentrations over-estimate actual expected PM_{10} concentrations because the maximum modeled concentrations from the proposed activities are assumed to coincide with the maximum measured background concentrations. However, the meteorological conditions that lead to both situations would be very different, and are not likely to occur at the same location and the same time.

The maximum short-term (3- and 24-hour) SO_2 emissions would be generated by drilling rigs and other diesel engines used during rig-up, drilling, and completion operations (sulfur is a trace element in diesel fuel). These SO_2 emissions would be temporary, occurring only during the temporary construction period at each well location. The maximum modeled concentrations (including representative background values of 8 $\mu g/m^3$) would be nearly 18 $\mu g/m^3$ (3-hour) and 12.5 $\mu g/m^3$ (24-hour).

Therefore, predicted short-term SO_2 concentrations would be below the 3-hour SO_2 National and Wyoming Ambient Air Quality Standards of 1,300 $\mu g/m^3$ (3-hour), as well as the Wyoming SO_2 Ambient Air Quality Standard of 260 $\mu g/m^3$ (24-hour). Since these SO_2 construction emissions would be temporary, PSD increments are not applicable.

Air pollutant dispersion modeling was also performed to quantify potential "reasonable, but conservative" CO, NO_2 and HAP impacts during operation, based on the period of maximum potential emissions and other emission sources located in the Project Area (including Alternative 1 and other reasonably foreseeable sources.) Operation emissions (primarily CO and NO_x) would occur due to increased compression requirements, including booster and reciprocating pipeline compressor stations. It is anticipated additional field-wide compression would be approximately 800,000 hp (at more than 250 new compressor station locations). Since produced natural gas is nearly pure methane and ethane, with little or no liquid hydrocarbons, no significant direct VOC emissions would occur due to well operations.

The maximum direct CO impacts during operation were predicted to be nearly 855 $\mu g/m^3$ (1-hour) and 796 $\mu g/m^3$ (8-hour). When these values are added to the assumed background concentrations of 3,500 $\mu g/m^3$ and 1,500 $\mu g/m^3$, respectively, they become 4354 $\mu g/m^3$ (1-hour) and 2295 $\mu g/m^3$ (8-hour), demonstrating compliance with both the Wyoming and NAAQS of 40,000 $\mu g/m^3$ (1-hour) and 10,000 $\mu g/m^3$ (8-hour).

Maximum direct NO_2 impacts during operations were predicted based on assumed oxides of nitrogen (NO_x) emissions from reasonably foreseeable CBM recovery wells, and booster and reciprocating pipeline compressor engines. A NO_x emissions rate of 1.5 g/hp-hr was used. Compressor engines recently permitted by the WDEQ-AQD have an average potential NO_x emission rate of 1.0 g/hp-

hr. The maximum potential near-field NO_2 concentrations were determined by multiplying maximum predicted NO_x concentrations by 0.75, in accordance with standard EPA methodology (40 CFR 51, Appendix W, Section 6.2.3).

The maximum predicted direct annual NO_2 impact was 14.2 $\mu g/m^3$, which is nearly 57 percent of the applicable annual PSD Class II increment of 25 $\mu g/m^3$. When this value is added to the assumed representative background concentration (16.5 $\mu g/m^3$), the resulting predicted maximum total impact of 30.7 $\mu g/m^3$ is also well below the applicable NO_2 NAAQS of 100 $\mu g/m^3$ (annual).

As stated previously, all NEPA analysis comparisons to the PSD Class II increments are intended to evaluate a threshold of concern, and do not represent a regulatory PSD Increment Consumption Analysis.

Maximum HAP (formaldehyde) impacts were predicted for the booster and reciprocating pipeline compressor engines. Since neither the WDEQ-AQD nor EPA have established HAP standards, predicted 8-hour HAP concentrations were compared to a range of 8-hour state maximum Acceptable Ambient Concentration Levels (AACL; EPA 1997a). The maximum predicted cumulative 8-hour formaldehyde impact was 11.5 $\mu g/m^3$, which is within the range of states' AACLs of 4.5 $\mu g/m^3$ (Pinnellas County Air Pollution Control Board, Florida) to 71 $\mu g/m^3$ (State of Nevada, Division of Environmental Protection, Air Quality Control). The maximum formaldehyde concentration was predicted to occur at 320 m (less then 1/4 mile) adjacent to a compressor station; as the distance from the emission source increases, the predicted concentrations decrease rapidly.

Long-term (70-year) exposures from suspected carcinogenic emissions (e.g., formaldehyde) were used to estimate the minimum distance for residential incremental cancer risk exposure below acceptable thresholds. These were calculated based on EPA (1997b) unit risk factors for carcinogenic constituents. Two estimates of cancer risk were made; one that corresponds to a most likely exposure (MLE) condition, and one reflective of the maximally exposed individual (MEI). The estimated cancer risks were adjusted to account for duration of exposure and time spent at home.

Under the MLE scenario, the estimated distance from the largest compressor engine to experience an incremental cancer risk below the 1×10^{-6} to 100×10^{-6} threshold (associated with long-term exposure to formaldehyde) would be 350 meters. Under the MEI analysis, the estimated distance would be 400 meters. Therefore, the predicted incremental cancer risks for the inhalation pathway all fall below the 1×10^{-6} to 100×10^{-6} threshold range beyond 400 meters from the largest compressor engine. This distance would be even further for smaller compressors. Given the conservative nature of these analyses, the predicted exposures are likely to overstate actual exposures, and the potential incremental cancer risks would not be significant.

When reviewing the predicted near-field development alternative impacts, it is important to understand the "reasonable, but conservative" assumptions made regarding potential resource development. In developing this analysis, there is uncertainty regarding ultimate development (i.e., number of wells, equipment to

be used, specific locations). The analysis was also based on a reasonably foreseeable development scenario, including several conservative assumptions:

- Maximum assumed background air pollutant concentrations were assumed to occur throughout the LOP at all locations in the region, even though monitoring is primarily conducted in urban or industrial areas, rather than the relatively clean rural areas. In addition, the maximum predicted air quality impacts would occur only in the vicinity of the anticipated emission sources. Actual impacts would be less further away from the predicted points of maximum.
- All emission sources were assumed to operate at their reasonably foreseeable maximum emission rates simultaneously throughout the LOP. Given the number of sources included in this analysis, the co-probability of such a scenario actually occurring over an entire year (or even 24-hours) is small. While this assumption is typically used in modeling analyses, the resulting predicted impacts will be overstated.
- All proposed natural gas wells were assumed to be fully operational (no dry holes), and remain operating (no shut ins) for about 7 years, with an overall 20-year LOP.
- The total proposed booster and reciprocating pipeline compression engines (nearly 800,000 hp) were assumed to operate at their rated capacities continuously throughout the LOP (no phased increases or reductions). In reality, compression equipment would be added or removed incrementally as required by the well field operation, compressor engines would operate below full horsepower ratings, and it is unlikely all compressor stations would operate at maximum levels simultaneously.
- Total predicted short-term air pollutant impact concentrations were assumed to be the sum of the assumed maximum background concentration, plus the predicted maximum cumulative modeled concentrations, which actually occur under very different meteorological conditions and are not likely to coincide.
- The HAP analyses assumed all equipment would operate simultaneously at the maximum emission levels continuously throughout the overall 20 year LOP.

Given these numerous "reasonable, but conservative" analysis assumptions, which may actually compound one another, the predicted impacts represent an upper estimate of potential air quality impacts which are unlikely to actually be reached. However, even applying these "reasonable, but conservative" analysis assumptions, predicted impacts are below applicable regulatory limits, and the scientific evidence is not compelling that reasonably foreseeable significant adverse impacts would occur.

It is important to note that before actual development could occur, the applicable air quality regulatory agencies (including the state, tribe or EPA) would review specific air pollutant emissions pre-construction permit applications that examine source-specific air quality impacts. As part of these permits (depending on source size), the air quality regulatory agencies could require additional air quality impacts analyses or mitigation measures. Thus, before development occurs, addi-

tional site-specific air quality analyses would be performed to ensure protection of air quality.

Alternatives 2A and 2B

Significant air quality impacts would not occur under this Alternative. Potential air quality impacts would be less than those described under Alternative 1 (Proposed Action) above.

Alternative 3

Significant air quality impacts would not occur under this Alternative. Potential air quality impacts would be less than those described under Alternative 1 (Proposed Action) above.

Impacts from Temporary Generation

The exact number of temporary natural gas and diesel generators for compressor stations cannot be predicted, but at any one time there may be as many as 400 portable diesel generators and 70 portable gas generators operating. Typical emission factors for these generators are shown on Table 4–10. Table 4–11 shows the potential ground-level concentrations resulting from operation of these temporary generators.

Table 4–10 Emission factors for Temporary Generation

Pollutant	Emission Factor Range (g/hp-hr)
NO_x	0.7 – 1.5
PM_{10}	0.03 – .07
SO_2	0.002
CO	0.3 – 2.0
VOC	0.5 – 1.0
HCHO	0.05 – 0.2

Table 4–11 Near-Field Concentrations from a Single Temporary Generator

Pollutant	Averaging Time	Concentration Range ($\mu g/m^3$)	WAAQS ($\mu g/m^3$)
NO_2	Annual	1.9 – 7.5	100
SO_2	Annual	0.007 – 0.013	60
	24 hour	0.09 – 0.3	260
	3 hour	0.2 – 0.4	1300
$PM_{10}/PM_{2.5}$	Annual	0.1 – 0.4	15
	24 hour	1.5 – 5.3	65
CO	8 hour	33.2 – 242.9	10,000
	1 hour	55.3 – 403.1	40,000

Cumulative Impacts

Based on a separate assessment predicting potential far-field (cumulative) air quality impacts (Argonne 2001), the EPA CALMET/CALPUFF dispersion model was used to predict maximum potential air quality impacts at downwind mandatory Federal PSD Class I areas, and other "sensitive receptors," to: 1) determine if the PSD Class I NO_2 increment might be exceeded; 2) calculate potential nitrate and sulfate atmospheric deposition (and their related impacts) in sensitive lakes; and 3) predict potential impacts to visibility (regional haze).

Meteorological information was assembled to characterize atmospheric transport and dispersion from several data sources, including:

- 20 km gridded MM4 (mesoscale model) values with continuous four-dimensional data assimilation.
- Hourly surface observations (wind speed, wind direction, temperature, cloud cover, ceiling height, surface pressure, relative humidity, and precipitation).
- Twice-daily upper air vertical profiles (wind speed, wind direction, temperature and pressure).
- PRISM adjusted hourly precipitation measurements.

Potential "reasonable, but conservative" air pollutant emissions from Alternative 1 (Proposed Action) sources were combined with other reasonably foreseeable facilities to determine the total potential cumulative air quality impacts. These other "reasonably foreseeable" facilities included development associated with: 1) approximately 458 emission sources permitted by the WDEQ-AQD; 2) approximately 34 emission sources permitted by the MTDEQ-AWM; and 3) approximately 13 emission sources permitted within the states of North Dakota, South Dakota and Nebraska.

As described under Alternative 1 above, potential NO_x emissions from reasonably foreseeable booster and reciprocating compressor stations, and SO_2 emissions from construction equipment, were analyzed to predict potential impacts at 16 PSD Class I areas located in Wyoming, Montana, North and South Dakota (Argonne 2001). Table 4–12 presents the maximum modeled concentration at the specified PSD Class I Area; other PSD Class I areas had lower predicted impacts. Therefore, all potential direct cumulative NO_2 and SO_2 impacts would be at or below applicable PSD Class I increments.

Table 4–12 Maximum Predicted PSD Class I Area Cumulative Impacts (in µg/m^3) - Alternative 1

Pollutant/Averaging Period	Class I Area	Maximum Modeled Concentration	Class I Increment
Nitrogen dioxide - Annual	Wind Cave NP	0.5	2.5
Sulfur dioxide - Annual	Wind Cave	0.13	2
Sulfur dioxide - 24-hour	N. Cheyenne Res.	1.38	5
Sulfur dioxide - 3-hour	N. Cheyenne Res.	3.69	25

It should be noted that this comparison is not a complete PSD Increment Consumption Analysis, but an assessment indicating that the increment would not be exceeded by the cumulative emission sources. Many of the potential air pollutant emission sources were analyzed at their maximum permitted levels; actual emissions and their related air quality impacts are typically less. At the time of a preconstruction air quality permit application, the applicable air quality regulatory agencies may require a much more detailed PSD Increment Consumption Analysis.

Several lakes within four FS designated wilderness areas were identified as being sensitive to atmospheric deposition and for which the most recent and complete data have been collected. The FS has also identified the following "Limit of Acceptable Change" regarding potential changes in lake chemistry: no more than a 10 percent change in acid neutralizing capacity (ANC) for those water bodies where the existing ANC is at or above 25 microequivalents per liter (μeq/l) and no more than a 1 μeq/l change for those extremely sensitive water bodies where the existing ANC is below 25 μeq/l. Based on a Rocky Mountain Region FS screening method (FS 2000), Table 4–13 demonstrates that potential impacts to sensitive lakes would be below applicable significance thresholds from the Alternative 1 emission sources. No sensitive lakes were identified by either the NPS or USFWS.

Table 4–13 Predicted Total Cumulative Change in Acid Neutralizing Capacity at Sensitive Area Lakes (percent change)

Sensitive Area	Lake	Baseline ANC (μeq/L)	Area (hectares)	Change (percent)	Thresholds (percent)
Bridger Wilderness Area	Black Joe Lake	69.0	890	0.8	10
	Deep Lake	61.0	205	0.9	10
	Hobbs Lake	68.0	293	0.3	10
Cloud Peak Wilderness Area	Emerald Lake	55.3	293	4.1	10
	Florence Lake	32.7	417	7.8	10
Fitzpatrick Wilderness Area	Ross Lake	61.4	4,455	0.4	10

Since the development alternative and cumulative air pollutant emission sources constitute many small sources spread out over a very large area, discrete visible plumes are not likely to affect the mandatory Federal PSD Class I areas, but the potential for cumulative visibility impacts (increased regional haze) is a concern. Regional haze degradation is caused by fine particles and gases scattering and absorbing light. Potential changes to regional haze are calculated in terms of a perceptible "just noticeable change" (1.0 deciview) in visibility when compared to background conditions.

A 1.0 deciview change is considered a small but noticeable change in haziness as described in the Preamble to the EPA Regional Haze Regulations (64 FR 35725, III.C.). A 1.0 deciview change is defined as about a 10 percent change in the extinction coefficient (corresponding to a 2 to 5 percent change in contrast, for a "black target" against a clear sky, at the most optically sensitive distance from an observer), which is a small but noticeable change in haziness under most circumstances when viewing scenes in mandatory Federal Class I areas.

It should be noted that a 1.0 deciview change is not a "just noticeable change" in all cases for all scenes. Visibility changes less than 1.0 deciview are likely to be perceptible in some cases, especially where the scene being viewed is highly sensitive to small amounts of pollution, such as due to preferential forward light scattering. Under other view-specific conditions, such as where the sight path to a scenic feature is less than the maximum visual range, a change greater than 1.0 deciview might be required to be a "just noticeable change."

However, this NEPA analysis is not designed to predict specific visibility impacts for specific views in specific mandatory Federal PSD Class I areas based on specific project designs, but to characterize reasonably foreseeable visibility conditions that are representative of a fairly broad geographic region, based on "reasonable, but conservative" emission source assumptions. This approach is consistent with both the nature of regional haze and the requirements of NEPA. At the time of a pre-construction air quality PSD permit application, the applicable air quality regulatory agency may require a much more detailed visibility impact analysis. Factors such as the magnitude of deciview change, frequency, time of the year, and the meteorological conditions during times when predicted visibility impacts are above the 1.0 deciview threshold (as well as inherent conservatism in the modeling analyses) should all be considered when assessing the significance of predicted impacts.

The FS, NPS and USFWS have published their "Final FLAG Phase I Report" (Federal Register, Vol. 66 No. 2, dated January 3, 2001), providing "a consistent and predictable process for assessing the impacts of new and existing sources on AQRVs" including visibility. For example, the FLAG report states "A cumulative effects analysis of new growth (defined as all PSD increment-consuming sources) on visibility impairment should be performed," and further, "If the visibility impairment from the proposed action, in combination with cumulative new source growth, is less than a change in extinction of 10 percent [1.0 deciview] for all time periods, the FLMs will not likely object to the proposed action." In addition, the FLAG procedures were also applied using WDEQ-AQD provided background extinction values.

Although the FLAG procedures were primarily designed to provide analysis guidance to Clean Air Act PSD permit applicants, Table 4–14 uses the "Final FLAG Phase I Report" procedures for this NEPA analysis.

Table 4–14 Predicted Visibility Impacts in PSD Class I Areas from Cumulative Sources — FLAG Method (Number of Days Predicted to Equal or Exceed a 1.0 Deciview "Just Noticeable Change")

Class I Area	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Badlands National Park	3	3	3	2
Bridger Wilderness Area	0	0	0	0
Fitzpatrick Wilderness Area	0	0	0	0
N. Absaroka Wilderness Area	1	0	0	0
N. Cheyenne Reservation	10	10	9	6
Washakie Wilderness Area	1	1	1	0
Wind Cave National Park	4	3	3	2

Based on multiple iterations of the non-steady state CALPUFF dispersion modeling system, including the CALMET meteorological model, for five different development alternatives, potential visibility impairment of 1.0 dV or greater ranged from none to ten days. In addition, the air quality impact assessment also analyzed potential visibility (regional haze) impacts at nine PSD Class II areas not subject to the Clean Air Act visibility protection regulations.

If visibility impacts are predicted to equal or exceed 1.0 deciview at any PSD Class I area based on the FLAG/WYO analysis, then a daily impact analysis based on monitored optical and relative humidity conditions should be performed.

Since the 1.0 deciview threshold was predicted to be reached at Northern Cheyenne Reservation based on the FLAG analysis methodology, the maximum modeled impacts to that area were compared to representative measured optical and relative humidity values on a daily basis.

When reviewing the predicted cumulative impacts, it is important to understand the "reasonable, but conservative" assumptions made regarding potential resource development. In developing this analysis, there is uncertainty regarding ultimate development (i.e., number of wells, equipment to be used, specific locations). The analysis was also based on a reasonably foreseeable development scenario, including several conservative assumptions:

- All emission sources were assumed to operate at their reasonably foreseeable maximum emission rates simultaneously throughout the LOP. Given the number of sources included in this analysis, the co-probability of such a scenario actually occurring over an entire year (or even 24-hours) is small. While this assumption is typically used in modeling analyses, the resulting predicted impacts will be overstated.
- All proposed natural gas wells were assumed to be fully operational (no dry holes), and remain operating (no shut ins) for about 7 years, with an overall 20-year LOP.
- The total proposed booster and reciprocating pipeline compression engines (nearly 800,000 hp) were assumed to operate at their rated capacities continuously throughout the LOP (no phased increases or reductions). In reality, compression equipment would be added or removed incrementally as required by the well field operation, compressor engines would operate below full horsepower ratings, and it is unlikely all compressor stations would operate at maximum levels simultaneously.
- The atmospheric deposition impact analysis assumed no other ecosystem components would affect lake chemistry for a full year (assuming no chemical buffering due to interaction with vegetation or soil materials).
- The visibility impact analysis assumed seasonal "natural background" optical conditions would occur simultaneously every day throughout each mandatory Federal PSD Class I Area, and that a 1.0 deciview "just noticeable change" would be a reasonably foreseeable significant adverse impact, although there is no applicable state, tribal or Federal regulatory visibility standards.

Table 4–15 Predicted Visibility Impacts in PSD Class I Areas — Daily Analysis Method (Number of Days Predicted to Equal or Exceed a 1.0 Deciview "Just Noticeable Change")

PSD Class I Area	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Northern Cheyenne Reservation											
Alternative 1	6	6	10	13	8	11	9	14	12	11	14
Alternative 2A	6	6	9	13	8	8	8	14	10	11	13
Alternative 3	4	3	7	9	4	4	6	9	5	6	7

Given these numerous "reasonable, but conservative" analysis assumptions, which may actually compound one another, the projected impacts represent an upper estimate of potential air quality impacts which are unlikely to actually be reached. However, even applying these "reasonable, but conservative" analysis assumptions, most predicted impacts are below assumed threshold limits, and scientific evidence is not compelling that reasonably foreseeable significant adverse impacts would occur.

It is important to note that before actual development could occur, the applicable air quality regulatory agencies (including the state, tribe or EPA) would review specific air pollutant emissions preconstruction permit applications which examine source-specific air quality impacts. As part of these permits (depending on source size), the air quality regulatory agencies could require additional air quality impacts analyses or mitigation measures. Thus, before development occurs, additional site-specific air quality analyses would be performed to ensure protection of air quality.

Vegetation

Direct effects to vegetation would occur from ground disturbance due to construction of well pads, compressor stations, ancillary facilities, associated pipelines, and roads. Short-term effects would occur where vegetated areas are disturbed but later reclaimed within one to three years of the initial disturbance. Long-term effects would occur where well pads, compressor stations, roads, water-handling facilities, or other semi-permanent facilities result in loss of vegetation and prevent reclamation for the life of the Project. These areas would be reclaimed during the abandonment phase. There would be some permanent loss of vegetation for roads and other facilities that are not reclaimed.

Indirect effects to vegetation would occur as a result of Project activities other than the direct disturbance or removal of vegetation. Possible indirect effects may include: 1) an increase in the potential for the spread of noxious weeds and displacement of native vegetation, due to increased ground disturbance in the Project Area; 2) alteration of vegetation type distribution due to changes in volume and rate of surface water flows, particularly changes in stream flow from intermittent to perennial; 3) alteration of ecosystem biodiversity due to changes in plant species composition, abundance, and distribution; and 4) changes in vegetation type distribution which are important to wildlife species dependent on these types as habitat.

Alternative 1

Direct Effects

Under Alternative 1, direct disturbance would be the primary impact to vegetation resources in the Project Area. Approximately 278,633 acres (3.5 percent of the Project Area) would be directly disturbed in the short-term. Of the 14 vegetation types within the Project Area, direct disturbance would occur across all land ownership types in 13 vegetation types including agriculture, barren, coniferous forest, forested riparian, herbaceous riparian, mixed-grass prairie, other shrublands, sagebrush shrublands, shortgrass prairie, shrubby riparian, urban/disturbed, water, and wet meadow Table 4–16. The aspen vegetation type would not be disturbed. Direct disturbance of vegetation would occur in each of the 18 subwatersheds within the Project Area (Table 4–17).

Table 4–16 Short-term Vegetation Disturbance by Surface Owner — Alternative 1

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	31	0	0	146	2,075	2,252
Aspen	0	0	0	0	0	0
Barren	362	0	4	286	2,578	3,229
Coniferous Forest	203	0	9	148	822	1,182
Forest Riparian	0	0	0	0	11	11
Herbaceous Riparian	0	6	0	0	0	6
Mixed Grass Prairie	2,518	11	303	4,060	29,181	36,073
Other Shrublands	11	0	0	17	28	56
Sagebrush Shrublands	8,800	22	3,606	5,375	68,174	85,978
Shortgrass Prairie	18,715	33	7,665	9,091	107,045	142,550
Shrubby Riparian	15	0	6	116	1,171	1,307
Urban/Disturbed	0	0	0	0	6	6
Water	0	0	0	10	403	413
Wet Meadow	20	0	22	707	4,820	5,569
Total	30,676	72	11,615	19,957	216,313	278,633

Table 4–17 Short-term Vegetation Disturbance by Sub-watershed — Alternative 1

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	22	0	6	0	0	0	0	0	28
Upper Tongue River	851	0	213	19	0	0	7,523	0	3,086	3,456	416	0	0	2,707	18,270
Middle Fork Powder River	0	0	0	10	6	0	22	33	22	39	0	0	0	0	132
North Fork Powder River	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6
Upper Powder River	69	0	1,106	259	0	0	8,530	0	29,900	55,008	128	0	0	463	95,462
South Fork Powder River	0	0	0	6	0	0	6	0	0	6	0	0	0	0	18
Salt Creek	0	0	0	59	0	0	0	0	204	1,004	0	0	0	0	1,268
Crazy Woman Creek	0	0	395	12	0	0	1,197	6	6,489	10,533	0	0	0	0	18,631
Clear Creek	1,124	0	205	39	0	0	6,130	6	4,491	6,495	509	0	403	1,774	21,176
Middle Powder River	27	0	43	206	0	0	1,478	0	2,031	2,833	6	0	0	88	6,712
Little Powder River	58	0	317	488	0	0	6,159	0	12,429	9,458	136	0	0	253	29,298
Little Missouri River	6	0	0	6	0	0	259	0	143	94	0	0	0	11	519
Antelope Creek	53	0	192	32	0	0	443	0	10,257	34,433	0	0	0	0	45,410
Dry Fork Cheyenne River	6	0	11	0	6	0	105	0	50	94	0	0	0	0	272
Upper Cheyenne River	0	0	28	10	0	0	266	0	2,003	1,496	0	0	0	0	3,803
Lightning Creek	6	0	6	0	0	0	116	11	105	28	0	0	0	0	272
Upper Belle Fourche River	52	0	697	37	0	0	3,695	0	14,696	17,573	113	0	10	273	37,146
Middle North Platte Casper	0	0	17	0	0	6	116	0	66	0	0	6	0	0	211
Total	2,252	0	3,229	1,182	11	6	36,073	56	85,978	142,550	1,307	6	413	5,569	278,633

The area of long-term disturbances associated with the Project would be less than the extent of disturbances presented in (Table 4–16 and Table 4–17). Long-term disturbance would affect 128,064 acres (1.6 percent of the Project Area). The initial area disturbed during the construction phase is typically larger than the area required for the operation phase. After completion of each well and associated roads and other facilities, portions of the disturbed areas would be reclaimed. Long-term disturbance would still occur in the same 13 vegetation types as would short-term disturbance, but the total area that remained disturbed would be less. Total long-term disturbance by land ownership type is shown in Table 4–18. The areal extent of vegetation that would be permanently lost is not known at this time because the percentage of roads to be left unreclaimed is not yet known.

Table 4–18 Long-term Vegetation Disturbance by Surface Owner — Alternative 1

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	17	0	0	73	998	1,088
Aspen	0	0	0	0	0	0
Barren	183	0	2	132	1,238	1,554
Coniferous Forest	122	0	37	86	493	738
Forest Riparian	0	0	0	0	9	9
Herbaceous Riparian	0	5	0	0	0	5
Mixed Grass Prairie	1,216	9	248	1,927	14,126	17,525
Other Shrublands	9	0	0	14	23	46
Sagebrush Shrublands	3,975	18	1,792	2,525	31,696	40,007
Shortgrass Prairie	8,218	27	3,413	4,„064	47,849	63,571
Shrubby Riparian	10	0	5	60	237	312
Urban/Disturbed	0	0	0	0	5	5
Water	0	0	0	5	202	207
Wet Meadow	10	0	18	345	2,627	3,001
Total	13,760	59	5,515	9,231	99,504	128,069

Long-term disturbance would also occur in all 18 sub-watersheds, but again in lesser amounts. The extent of long-term disturbance in each sub-watershed is shown in Table 4–19.

Several options for handling CBM produced waters, including surface discharge, infiltration, containment, land application disposal (LAD), and injection, would also be implemented and would result in short- and long-term disturbance to vegetation in the Project Area. Details of the water handling options are discussed in Chapter 2. Water handling options would directly disturb vegetation in ten of the 18 sub-watersheds within the Project Area (Tables 2-6 and 2-7). The total amount of vegetation disturbed as a result of water handling methods (32,685 acres) for Alternative 1 would be more than that for Alternative 3 because of the greater number of wells, but less than both Alternatives 2A and 2B, where the same number of wells would be drilled, but different water handling methods would be used.

Table 4–19 Long-Term Vegetation Disturbance by Sub-watershed — Alternative 1

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	18	0	5	0	0	0	0	0	23
Upper Tongue River	415	0	102	10	0	0	3,559	0	1,431	1,647	156	0	0	1,326	8,645
Middle Fork Powder River	0	0	0	9	5	0	18	27	18	32	0	0	0	0	109
North Fork Powder River	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
Upper Powder River	36	0	513	129	0	0	3,836	0	13,478	24,744	14	0	0	242	42,991
South Fork Powder River	0	0	0	5	0	0	5	0	0	5	0	0	0	0	15
Salt Creek	0	0	0	23	0	0	0	0	100	399	0	0	0	0	523
Crazy Woman Creek	0	0	154	8	0	0	511	5	2,777	4,511	0	0	0	0	7,965
Clear Creek	539	0	105	24	0	0	3,011	5	2,236	3,188	107	0	202	992	10,409
Middle Powder River	14	0	24	106	0	0	740	0	928	1,347	5	0	0	59	3223
Little Powder River	24	0	172	366	0	0	3,162	0	6,459	4,946	22	0	0	198	15,349
Little Missouri River	5	0	0	5	0	0	212	0	117	77	0	0	0	9	425
Antelope Creek	20	0	74	15	0	0	173	0	3,897	13,053	0	0	0	0	17,232
Dry Fork Cheyenne River	5	0	9	0	5	0	86	0	41	77	0	0	0	0	223
Upper Cheyenne River	0	0	16	7	0	0	98	0	967	737	0	0	0	0	1,825
Lightning Creek	5	0	5	0	0	0	95	9	86	23	0	0	0	0	223
Upper Belle Fourche River	25	0	367	32	0	0	1,901	0	7,413	8,785	9	0	5	175	18,712
Middle North Platte Casper	0	0	14	0	0	5	95	0	54	0	0	5	0	0	173
Total	1,088	0	1,554	738	9	5	17,525	46	40,007	63,571	312	5	207	3,001	128,069

Where surface discharge is selected as the water handling option, produced water from CBM wells would be gathered for surface discharge, feeding a small stock reservoir or constructed infiltration basin designed for flow through (including possible passive or active treatment) and subsequent discharge to a nearby surface drainage. Surface discharge associated with Alternative 1 would cause direct disturbance to vegetation on 7,296 acres typically from the construction of flow through ponds. Where infiltration is selected as the water handling option, shallow impoundments would be constructed in upland or bottomland areas where soils would allow infiltration of produced water. Water would not be released from these impoundments into surface drainages. Atomizers would be used to enhance water evaporation. The construction of infiltration impoundments would result in direct impacts to 14,566 acres of vegetation. Where containment is selected as the water handling option, shallow impoundments would be constructed in upland areas where soils would allow only minimal infiltration. Water would not be released from these impoundments into surface drainages. Atomizers would be used to enhance water evaporation. Direct effects to vegetation due to the creation of containment reservoirs would encompass 5,169 acres. Where LAD is selected as the water handling option, disposal likely would be accomplished using atomizers or irrigation equipment under a disposal-rest rotation cycle consisting of disposal, soil amendment, rest, disposal, etc., until the limitations of repeated soil amendments are reached, and the site reclaimed. It is assumed that all water would either evaporate or be consumed by vegetation and that infiltration and surface runoff would be negligible. Direct effects to vegetation at LAD sites would result in the direct disturbance of 1,780 acres. Where injection is selected as the water handling option, direct effects to vegetation caused by construction at injection well sites would result in direct disturbance to vegetation on 3,873 acres.

Indirect Effects

Implementation of Alternative 1 would cause indirect effects to vegetation types within the Project Area. Following the life of the Project, most facilities would be removed and their disturbed areas would be reclaimed and returned to pre-project uses. This restoration would typically include replacing salvaged topsoil, regrading where necessary, reseeding disturbed areas, and controlling noxious weeds. Reclamation of all native vegetation types present in the Project Area, particularly sagebrush shrublands, would be difficult to achieve. Efforts directed toward successful reclamation of all Project disturbances would be continued until reclamation is successful. Replacement of pre-disturbance vegetation communities would potentially be a long-term effort due to the difficulty in replicating native plant communities. Forested areas, shrublands, and even native grasslands would remain in a low-diversity state for an extended period of time (i.e., years to decades) until natural plant species recruitment re-establishes the pre-disturbance level of diversity.

Disturbances from construction would increase the potential for the invasion and establishment of noxious weed species. Noxious weeds tend to be aggressive invaders of disturbed areas. Disturbances associated with the construction of well pads, compressor stations, roads, reservoirs, and other facilities would provide opportunities for the invasion and establishment of noxious weeds. The extent of these invasions is difficult to predict and would be determined by many factors,

including the extent of disturbed areas, the extent of existing weed infestations that would provide a seed source, the amount of equipment movement from areas infested with weeds to areas not yet infested, the effectiveness of mitigation measures designed to prevent noxious weed infestations, and the time lag between the end of disturbance and the successful completion of reclamation.

Surface discharge of produced water from CBM wells has the potential to alter vegetation patterns in areas downstream of discharge points. The increased availability of water along normally dry stream channels would cause an increase in the extent of riparian and wetland vegetation, and a corresponding decrease in upland vegetation that formerly occupied these areas. This shift in vegetation types would provide another type of disturbance that could be exploited by noxious weed species. The extent of these changes is dependent on the locations chosen for discharge points and on the existing vegetation downstream of these points.

Other than the alteration of vegetation along drainages, other changes in vegetation patterns may occur. Large, contiguous stands of vegetation would be fragmented by the construction of well pads, roads, pipeline corridors, and other facilities. Disturbance followed by reclamation would alter the species composition of reclaimed areas when compared with undisturbed areas by replacing diverse native communities with communities consisting of a few favored reclamation species.

The increased availability of water at LAD sites would increase ground cover and productivity and alter species composition, thus providing a potential opportunity for aggressive species to establish, including noxious weeds. Water application at LAD sites would likely reduce the presence of certain plant species that are not tolerant of irrigation, such as sagebrush, while favoring species that are capable of exploiting the increased amount of water that would be available. The introduction of salts in produced water at LAD sites could alter soil chemistry and affect both plant species composition and biomass production. Excessive salt build-up in soils could result in decreases in productivity and loss of native species that are sensitive to high salt concentrations. Soil chemistry would be monitored during the life of the project and mitigation measures applied to reduce these impacts. Use of a rest-rotation system of water application, or the use of soil amendments to reduce salt concentrations are two possible mitigations. These measures would be developed on a site-specific basis, taking into account local soil properties, vegetation species present, the particular salts or other contaminants that are causing problems, and the objectives of the managing agency or surface owner.

The long-term effect of these shifts in vegetation patterns would be a reduction in biodiversity within and adjacent to disturbed areas. Where the native vegetation provides an essential component of wildlife habitat, such as the requirement of sage grouse for large, healthy stands of sagebrush, these shifts in vegetation patterns would result in decreased habitat quality for wildlife. Some of these changes in vegetation would occur in areas that have been specifically identified as being important to the conservation of biological diversity. The alteration and potential loss of biodiversity associated with project-related activities is difficult to quantify, but is not expected to have any substantial effect on biodiversity in

the Project Area as a whole or within each sub-watershed. Even if all plant species diversity in the entire disturbed area were to be reduced to some rudimentary level, only a small percentage of the landscape in each sub-watershed would be affected. The remaining undisturbed vegetation would still retain a level of biodiversity essentially equivalent to pre-project conditions.

Alternatives 2A and 2B

Direct Effects

Under Alternative 2, direct disturbance would be similar to Alternative 1. Within Alternative 2, two different ratios of the various water handling options (Alternatives 2A and 2B) have been analyzed. All disturbance associated with these alternatives would occur in the same vegetation types, land ownerships, and sub-watersheds as Alternative 1. Table 4–20 and Table 4–24 show the direct, short-term disturbance by surface owner for Alternatives 2A and 2B, respectively. Table 4–21 and Table 4–25 show the direct, long-term disturbance by surface owner for Alternatives 2A and 2B, respectively. Table 4–22 and Table 4–26 show the direct, short-term disturbance by sub-watershed for Alternatives 2A and 2B, respectively. Table 4–23 and Table 4–27 show the direct, long-term disturbance by sub-watershed for Alternatives 2A and 2B, respectively. Total vegetation disturbance under Alternative 2A would encompass 297,527 acres (3.8 percent of the Project Area) in the short-term and 146,963 acres (1.9 percent of the Project Area) in the long-term. Total vegetation disturbance under Alternative 2B would encompass 289,501 acres (3.7 percent of the Project Area) in the short-term and 138,937 acres (1.8 percent of the Project Area) in the long-term.

Table 4–20 Short-term Vegetation Disturbance by Surface Owner — Alternative 2A

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	33	0	0	155	2,192	2,379
Aspen	0	0	0	0	0	0
Barren	390	0	4	311	2,774	3,479
Coniferous Forest	215	0	10	157	868	1,250
Forest Riparian	0	0	0	0	11	11
Herbaceous Riparian	0	6	0	0	0	6
Mixed Grass Prairie	2,692	11	303	4,331	31,065	38,402
Other Shrublands	11	0	0	17	28	56
Sagebrush Shrublands	9,402	22	3,817	5,773	72,900	91,914
Shortgrass Prairie	19,901	33	8,208	9,731	114,462	152,335
Shrubby Riparian	15	0	6	123	1,200	1,344
Urban/Disturbed	0	0	0	0	6	6
Water	0	0	0	11	430	441
Wet Meadow	21	0	22	751	5,110	5,905
Total	32,680	72	12,369	21,360	231,046	297,527

The primary difference between Alternative 1 and 2, in terms of direct disturbance of vegetation, would be in the relative proportion of disturbance caused by the different types of water disposal methods. Water handling options would directly disturb vegetation in ten of the 18 sub-watersheds within the Project Area (Tables 2-23 and 2-24 for Alternative 2A; Tables 2-25 and 2-26 for Alternative

2B). The total amount of vegetation disturbed as a result of water handling methods for Alternative 2A (51,579 acres) and Alternative 2B (43,553 acres) is more than for Alternative 1 because the construction of impoundments for either infiltration or containment purposes causes greater surface disturbance than direct discharge to surface drainages. Total disturbance for both of these alternatives is greater than for Alternative 3 because that alternative contains many fewer new wells.

Table 4–21 Long-term Vegetation Disturbance by Surface Owner — Alternative 2A

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	18	0	0	82	1,114	1,215
Aspen	0	0	0	0	0	0
Barren	210	0	2	156	1,435	1,804
Coniferous Forest	134	0	38	95	539	806
Forest Riparian	0	0	0	0	9	9
Herbaceous Riparian	0	5	0	0	0	5
Mixed Grass Prairie	1,391	9	248	2,197	16,009	19,854
Other Shrublands	9	0	0	14	23	46
Sagebrush Shrublands	4,581	18	2,001	2,923	36,420	45,943
Shortgrass Prairie	9,412	27	3,951	4,704	55,262	73,356
Shrubby Riparian	11	0	5	67	266	349
Urban/Disturbed	0	0	0	0	5	5
Water	0	0	0	6	229	235
Wet Meadow	11	0	18	390	2,918	3,337
Total	15,778	59	6,262	10,634	114,230	146,963

Where surface discharge is selected as the water handling option, surface discharge associated with Alternative 2A would cause direct disturbance to vegetation on 9,956 acres. Surface discharge associated with Alternative 2B would cause direct disturbance to vegetation on 4,769 acres. Where infiltration is selected as the water handling option, direct effects to vegetation due to the construction of infiltration reservoirs would encompass 32,253 acres for Alternative 2A and 23,446 acres for Alternative 2B. Where containment is selected as the water handling option, direct effects to vegetation due to the creation of containment reservoirs would encompass 5,941 acres for Alternative 2A and 4,939 acres for Alternative 2B. Where LAD is selected as the water handling option, direct effects to vegetation would result in the direct disturbance of 6,296 acres for both Alternative 2A and Alternative 2B. Where injection is selected as the water handling option, direct effects to vegetation caused by construction at injection well sites would result in direct disturbance to vegetation on 4,103 acres for both Alternative 2A and Alternative 2B.

Table 4–22 Short-term Vegetation Disturbance by Sub-watershed — Alternative 2A

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	22	0	6	0	0	0	0	0	28
Upper Tongue River	887	0	233	20	0	0	7,934	0	3,797	3,976	528	0	0	2,,705	20,079
Middle Fork Powder River	0	0	0	11	6	0	22	33	33	59	0	0	0	0	164
North Fork Powder River	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6
Upper Powder River	84	0	1,159	283	0	0	8,941	0	31,112	57,208	140	0	0	563	99,489
South Fork Powder River	0	0	0	6	0	0	6	0	0	6	0	0	0	0	18
Salt Creek	0	0	0	64	0	0	0	0	304	1,014	0	0	0	0	1,383
Crazy Woman Creek	0	0	436	12	0	0	1,297	6	6,789	11,528	0	0	0	0	20,067
Clear Creek	1,180	0	225	41	0	0	6,431	6	5,191	6,706	461	0	428	1,922	22,591
Middle Powder River	32	0	51	221	0	0	1,588	0	2,031	3,163	11	0	0	88	7,185
Little Powder River	62	0	351	505	0	0	6,561	0	12,829	10,139	128	0	0	293	30,868
Little Missouri River	7	0	0	6	0	0	359	0	153	104	0	0	0	11	640
Antelope Creek	58	0	224	33	0	0	483	0	11,278	36,503	0	0	0	0	48,579
Dry Fork Cheyenne River	7	0	13	0	6	0	128	0	50	104	0	0	0	0	308
Upper Cheyenne River	0	0	33	10	0	0	366	0	2,103	1,624	0	0	0	0	4,136
Lightning Creek	7	0	6	0	0	0	126	11	105	28	0	0	0	0	283
Upper Belle Fourche River	55	0	730	39	0	0	4,016	0	16,067	20,173	77	0	13	323	41,493
Middle North Platte Casper	0	0	19	0	0	6	116	0	66	0	0	6	0	0	212
Total	2,379	0	3,479	1,250	11	6	38,402	56	91,914	152,335	1,344	6	441	5,905	297,527

Table 4–23 Long-term Vegetation Disturbance by Sub-watershed — Alternative 2A

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	28	0	5	0	0	0	0	0	33
Upper Tongue River	475	0	112	10	0	0	3,900	0	1,631	1,757	166	0	0	1,426	9,476
Middle Fork Powder River	0	0	0	9	5	0	28	27	18	32	0	0	0	0	119
North Fork Powder River	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
Upper Powder River	39	0	614	139	0	0	4,187	0	14,479	27,075	16	0	0	282	46,830
South Fork Powder River	0	0	0	5	0	0	5	0	0	5	0	0	0	0	15
Salt Creek	0	0	0	24	0	0	0	0	110	519	0	0	0	0	654
Crazy Woman Creek	0	0	164	8	0	0	631	5	3,777	5,921	0	0	0	0	10,505
Clear Creek	570	0	115	24	0	0	3,352	5	2,836	3,418	117	0	229	1,089	11,755
Middle Powder River	16	0	34	116	0	0	940	0	1,128	1,567	6	0	0	59	3,866
Little Powder River	34	0	182	403	0	0	3,683	0	7,482	5,739	36	0	0	257	17,816
Little Missouri River	6	0	0	5	0	0	232	0	117	87	0	0	0	9	456
Antelope Creek	30	0	84	25	0	0	293	0	4,938	16,174	0	0	0	0	21,544
Dry Fork Cheyenne River	5	0	9	0	5	0	96	0	41	87	0	0	0	0	243
Upper Cheyenne River	0	0	26	7	0	0	108	0	1,017	1,047	0	0	0	0	2,205
Lightning Creek	5	0	5	0	0	0	105	9	86	43	0	0	0	0	253
Upper Belle Fourche River	35	0	446	32	0	0	2,156	0	8,224	9,885	9	0	6	215	21,008
Middle North Platte Casper	0	0	14	0	0	5	105	0	54	0	0	5	0	0	182
Total	1,215	0	1,,804	806	9	5	19,854	46	45,943	73,356	349	5	235	3,337	146,963

Table 4–24 Short-term Vegetation Disturbance by Surface Owner — Alternative 2B

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	31	0	0	147	2,094	2,272
Aspen	0	0	0	0	0	0
Barren	378	0	4	300	2,692	3,374
Coniferous Forest	210	0	10	154	849	1,223
Forest Riparian	0	0	0	0	11	11
Herbaceous Riparian	0	6	0	0	0	6
Mixed Grass Prairie	2,598	11	303	4,185	30,048	37,145
Other Shrublands	11	0	0	17	28	56
Sagebrush Shrublands	9,156	22	3,731	5,610	70,968	89,488
Shortgrass Prairie	19,443	33	7,998	9,483	111,594	148,550
Shrubby Riparian	15	0	6	117	1,176	1,314
Urban/Disturbed	0	0	0	0	6	6
Water	0	0	0	10	408	418
Wet Meadow	20	0	22	716	4,879	5,637
Total	31,863	72	12,073	20,741	224,752	289,501

Table 4–25 Long-term Vegetation Disturbance by Surface Owner — Alternative 2B

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	17	0	0	75	1,017	1,108
Aspen	0	0	0	0	0	0
Barren	199	0	2	146	1,353	1,699
Coniferous Forest	129	0	38	91	521	779
Forest Riparian	0	0	0	0	9	9
Herbaceous Riparian	0	5	0	0	0	5
Mixed Grass Prairie	1,296	9	248	2,051	14,993	18,597
Other Shrublands	9	0	0	14	23	46
Sagebrush Shrublands	4,333	18	1,916	2,761	34,489	43,517
Shortgrass Prairie	8,951	27	3,743	4,456	52,395	69,571
Shrubby Riparian	10	0	5	61	242	319
Urban/Disturbed	0	0	0	0	5	5
Water	0	0	0	6	207	212
Wet Meadow	10	0	18	354	2,686	3,069
Total	14,955	59	5,968	10,015	107,939	138,937

Table 4–26 Short-term Vegetation Disturbance by Sub-watershed — Alternative 2B

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	22	0	6	0	0	0	0	0	28
Upper Tongue River	860	0	233	20	0	0	7,724	0	3,486	3,756	558	0	0	2,637	19,273
Middle Fork Powder River	0	0	0	11	6	0	22	33	22	39	0	0	0	0	133
North Fork Powder River	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6
Upper Powder River	69	0	1,143	273	0	0	8,697	0	30,808	56,308	130	0	0	503	97,930
South Fork Powder River	0	0	0	6	0	0	6	0	0	6	0	0	0	0	18
Salt Creek	0	0	0	64	0	0	0	0	204	1,003	0	0	0	0	1,272
Crazy Woman Creek	0	0	422	12	0	0	1,197	6	6,489	11,133	0	0	0	0	19,258
Clear Creek	1,135	0	215	41	0	0	6,331	6	5,091	6,795	311	0	408	1,782	22,115
Middle Powder River	27	0	43	211	0	0	1,578	0	2,231	3,033	36	0	0	88	7,247
Little Powder River	58	0	337	498	0	0	6,461	0	13,129	10,259	219	0	0	283	31,244
Little Missouri River	6	0	0	6	0	0	259	0	143	94	0	0	0	11	519
Antelope Creek	53	0	202	33	0	0	443	0	10,458	35,533	0	0	0	0	46,722
Dry Fork Cheyenne River	6	0	12	0	6	0	105	0	50	94	0	0	0	0	273
Upper Cheyenne River	0	0	28	10	0	0	266	0	2,103	1,696	0	0	0	0	4,103
Lightning Creek	6	0	6	0	0	0	116	11	105	28	0	0	0	0	272
Upper Belle Fourche River	52	0	717	39	0	0	3,796	0	15,097	18,773	61	0	10	333	38,878
Middle North Platte Casper	0	0	17	0	0	6	116	0	66	0	0	6	0	0	211
Total	2,272	0	3,374	1,223	11	6	37,145	56	89,488	148,550	1,314	6	418	5,637	289,501

Table 4–27 Long-term Vegetation Disturbance by Sub-watershed — Alternative 2B

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	18	0	5	0	0	0	0	0	23
Upper Tongue River	421	0	122	10	0	0	3,660	0	1,631	1,947	160	0	0	1,336	9,286
Middle Fork Powder River	0	0	0	9	5	0	18	27	18	32	0	0	0	0	109
North Fork Powder River	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
Upper Powder River	40	0	554	139	0	0	3,937	0	14,586	26,745	14	0	0	252	46,266
South Fork Powder River	0	0	0	5	0	0	5	0	0	5	0	0	0	0	15
Salt Creek	0	0	0	24	0	0	0	0	100	499	0	0	0	0	624
Crazy Woman Creek	0	0	174	8	0	0	611	5	3,077	4,911	0	0	0	0	8,785
Clear Creek	545	0	115	24	0	0	3,112	5	2,436	3,488	110	0	207	1,013	11,055
Middle Powder River	14	0	24	106	0	0	860	0	928	1,757	5	0	0	59	3,753
Little Powder River	28	0	182	396	0	0	3,462	0	7,059	4,646	22	0	0	222	16,017
Little Missouri River	5	0	0	5	0	0	232	0	117	77	0	0	0	9	445
Antelope Creek	20	0	84	15	0	0	273	0	4,198	15,234	0	0	0	0	19,824
Dry Fork Cheyenne River	5	0	9	0	5	0	86	0	41	77	0	0	0	0	223
Upper Cheyenne River	0	0	16	7	0	0	98	0	1,167	745	0	0	0	0	2,033
Lightning Creek	5	0	5	0	0	0	95	9	86	23	0	0	0	0	223
Upper Belle Fourche River	25	0	401	32	0	0	2,021	0	8,014	9,385	9	0	5	178	20,070
Middle North Platte Casper	0	0	14	0	0	5	104	0	54	0	0	5	0	0	182
Total	1,108	0	1,699	779	9	5	18,597	46	43,517	69,571	319	5	212	3,069	138,937

Indirect Effects

Indirect effects to vegetation as a result of Alternative 2 (both 2A and 2B) would be similar to those for Alternative 1. Disturbances associated with the construction of well pads, compressor stations, roads, reservoirs, and other facilities would provide opportunities for the invasion and establishment of noxious weeds. The increased availability of water at LAD sites would increase ground cover and alter the species composition by providing opportunity for aggressive species, including noxious weeds, to establish.

Surface discharge of produced water from CBM wells has the potential to alter vegetation patterns in areas downstream of discharge points. This shift in vegetation types would provide another type of disturbance that could be exploited by noxious weed species. Disturbance followed by reclamation would alter the species composition of reclaimed areas. The long-term effect of these shifts in vegetation patterns would be a reduction in biodiversity within and adjacent to disturbed areas. The differences between the two water-handling scenarios in terms of indirect impacts are expected to be in proportion to the differences in direct impacts.

Alternative 3

Direct Effects

Under Alternative 3, direct disturbance would be the primary impact to vegetation resources in the Project Area. Approximately 112,299 acres (1.4 percent of the Project Area) would be directly disturbed in the short-term. Of the 14 vegetation types within the Project Area, direct short-term disturbance would occur across all land ownership types in 12 vegetation types including agriculture, barren, coniferous forest, forested riparian, mixed-grass prairie, other shrublands, sagebrush shrublands, shortgrass prairie, shrubby riparian, urban/disturbed, water, and wet meadow (Table 4–28). Direct disturbance of vegetation would occur in 17 of the 18 sub-watersheds within the Project (Table 4–29). The only sub-watershed not affected would be the North Fork Powder River sub-watershed.

Table 4–28 Short-term Vegetation Disturbance by Surface Owner — Alternative 3

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	0	0	0	146	1,958	2,105
Aspen	0	0	0	0	0	0
Barren	0	0	0	290	1,006	1,296
Coniferous Forest	0	0	0	146	211	358
Forest Riparian	0	0	0	0	11	11
Herbaceous Riparian	0	0	0	0	0	0
Mixed Grass Prairie	0	0	0	4,055	17,375	21,430
Other Shrublands	0	0	0	6	17	23
Sagebrush Shrublands	0	0	0	5,181	27,467	32,647
Shortgrass Prairie	0	0	0	8,474	39,282	47,756
Shrubby Riparian	0	0	0	116	471	587
Urban/Disturbed	0	0	0	0	6	6
Water	0	0	0	10	394	404
Wet Meadow	0	0	0	708	4,968	5,676
Total	0	0	0	19,133	93,166	112,299

The area of long-term disturbances associated with the Project would be less than the extent of disturbances presented in Table 4–28. Long-term disturbance would affect 52,231 acres (0.6 percent of the Project Area). The initial area disturbed during the construction phase is typically larger than the area required for the operation phase. After completion of each well and associated roads and other facilities, portions of the disturbed areas would be reclaimed. Long-term disturbance would still occur in the same twelve vegetation types as would short-term disturbance, but the total area that remained disturbed would be less. Total long-term disturbance by land ownership type is shown in Table 4–30. Long-term disturbance would also occur in the same seventeen sub-watersheds, but again in lesser amounts. The extent of long-term disturbance in each sub-watershed is shown in Table 4–31.

The total amount of vegetation disturbed as a result of water handling methods for Alternative 3 would be less than any of the other alternatives because fewer wells would be drilled and less water would be produced, requiring fewer water handling facilities. Discharge of produced water associated with Alternative 3 would cause direct disturbance to vegetation on 14,384 acres (Tables 2-30 and 2-31).

Where surface discharge is selected as the water handling option, discharge of produced water associated with Alternative 3 would cause direct disturbance to vegetation on 8,376 acres. Where infiltration is selected as the water handling option, direct effects to vegetation due to the construction of infiltration reservoirs would encompass 7,141 acres for Alternative 3. Where containment is selected as the water handling option, direct effects to vegetation due to the creation of containment reservoirs would encompass 2,159 acres. Where LAD is selected as the water handling option, direct effects to vegetation would result in the direct disturbance of 808 acres. Where injection is selected as the water handling option, direct effects to vegetation caused by construction at injection well sites would result in direct disturbance to vegetation on 1,763 acres.

Indirect Effects

Implementation of Alternative 3 would result in lower potential for the occurrence of indirect effects to vegetation types within the Project Area than Alternatives 1 or 2, due to the reduced number of wells, roads, ancillary facilities, pipelines, and water handling facilities. Following the life of the project, most roads and facilities would be removed and their disturbed areas would be reclaimed and returned to pre-project uses.

Disturbances associated with the construction of well pads, compressor stations, roads, containment reservoirs, and other facilities would provide opportunities for the invasion and establishment of noxious weeds. The increased availability of water at LAD sites would increase ground cover and alter the species composition by providing opportunity for invasive exotic species to establish.

Table 4–29 Short-term Vegetation Disturbance by Sub-watershed — Alternative 3

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	22	0	6	0	0	0	0	0	28
Upper Tongue River	825	0	174	20	0	0	6,595	0	2,523	2,341	317	0	0	2,652	15,446
Middle Fork Powder River	0	0	0	0	5.5	0	6	6	6	22	0	0	0	0	46
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	42	0	316	38	0	0	3,167	0	7,318	11,999	21	0	0	440	23,340
South Fork Powder River	0	0	0	6	0	0	6	0	17	6	0	0	0	0	35
Salt Creek	0	0	0	0	0	0	0	0	114	489	0	0	0	0	602
Crazy Woman Creek	0	0	75	6	0	0	680	0	2,005	3,409	0	0	0	0	6,174
Clear Creek	1,088	0	139	26	0	0	4,284	6	2,572	3,417	211	0	394	1,897	14,033
Middle Powder River	6	0	17	38	0	0	329	0	450	521	6	0	0	66	1,433
Little Powder River	58	0	105	181	0	0	3,402	0	5,147	3,701	26	0	0	260	12,878
Little Missouri River	6	0	0	0	0	0	94	0	22	39	0	0	0	11	172
Antelope Creek	53	0	107	27	0	0	272	0	3,229	11,268	0	0	0	0	14,956
Dry Fork Cheyenne River	6	0	0	0	5.5	0	39	0	11	33	0	0	0	0	95
Upper Cheyenne River	0	0	0	0	0	0	25	0	450	485	0	0	0	0	960
Lightning Creek	0	0	0	0	0	0	61	11	39	17	0	0	0	0	128
Upper Belle Fourche River	21	0	364	17	0	0	2,394	0	8,706	10,010	6	0	10	351	21,880
Middle North Platte Casper	0	0	0	0	0	0	55	0	33	0	0	6	0	0	94
Total	2,105	0	1,296	358	11	0	21,430	23	32,647	47,756	587	6	404	5,676	112,299

Table 4–30 Long-term Vegetation Disturbance by Surface Owner — Alternative 3

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	0	0	0	73	940	1,014
Aspen	0	0	0	0	0	0
Barren	0	0	0	134	492	626
Coniferous Forest	0	0	0	84	125	210
Forest Riparian	0	0	0	0	9	9
Herbaceous Riparian	0	0	0	0	0	0
Mixed Grass Prairie	0	0	0	1,934	8,361	10,295
Other Shrublands	0	0	0	5	14	19
Sagebrush Shrublands	0	0	0	2,461	12,851	15,311
Shortgrass Prairie	0	0	0	3,810	17,739	21,549
Shrubby Riparian	0	0	0	60	234	294
Urban/Disturbed	0	0	0	0	5	5
Water	0	0	0	5	198	203
Wet Meadow	0	0	0	346	2,350	2,696
Total	0	0	0	8,914	43,317	52,231

Surface discharge of produced water from CBM wells has the potential to alter vegetation patterns in areas downstream of discharge points. This shift in vegetation types would provide another type of disturbance that could be exploited by noxious weed species. Disturbance followed by reclamation would alter the species composition of reclaimed areas. The long-term effect of these shifts in vegetation patterns would be a reduction in biodiversity within and adjacent to disturbed areas. This effect would be less than Alternatives 1, 2A, and 2B for Alternative 3.

Cumulative Effects

Implementation of each of the alternatives would contribute to cumulative effects to vegetation in the Project Area. Cumulative short- and long-term disturbance to vegetation by alternative for each surface owner is shown in Table 4–32. Cumulative short- and long-term disturbance to vegetation by alternative for each watershed is shown in Table 4–33. Included in Table 4–32 and Table 4–33 are the cumulative direct effects of oil and gas (both conventional and CBM) development, including projected effects of CBM development on private surface lands with private mineral ownership. The Alternative 3 data do not include potential new federal wells that would be developed in response to drainage situations caused by production on adjacent state or fee minerals. Additional oil and gas development (both conventional and CBM) may occur at a later date beyond the level of development being considered in this analysis. Other activities contributing to cumulative effects on vegetation in the Project Area include: coal mining; uranium mining; sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban housing development.

Table 4–31 Long-term Vegetation Disturbance by Sub-watershed — Alternative 3

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	18	0	5	0	0	0	0	0	23
Upper Tongue River	401	0	84	10	0	0	3,110	0	1,161	1,104	156	0	0	1,253	7,278
Middle Fork Powder River	0	0	0	0	5	0	5	5	5	18	0	0	0	0	38
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	23	0	146	18	0	0	1,379	0	3,319	5,399	9	0	0	185	10,477
South Fork Powder River	0	0	0	5	0	0	5	0	0	5	0	0	0	0	15
Salt Creek	0	0	0	0	0	0	0	0	52	189	0	0	0	0	240
Crazy Woman Creek	0	0	33	5	0	0	283	0	849	1,455	0	0	0	0	2,624
Clear Creek	521	0	70	15	0	0	2,116	5	1,274	1,670	106	0	198	905	6,879
Middle Powder River	5	0	10	20	0	0	172	0	223	236	5	0	0	44	715
Little Powder River	24	0	54	114	0	0	1,651	0	2,505	1,923	13	0	0	138	6,420
Little Missouri River	5	0	0	0	0	0	77	0	18	32	0	0	0	9	141
Antelope Creek	20	0	40	10	0	0	104	0	1,226	4,259	0	0	0	0	5,659
Dry Fork Cheyenne River	5	0	0	0	5	0	32	0	9	27	0	0	0	0	78
Upper Cheyenne River	0	0	0	0	0	0	12	0	232	257	0	0	0	0	501
Lightning Creek	0	0	0	0	0	0	50	9	32	14	0	0	0	0	105
Upper Belle Fourche River	10	0	190	14	0	0	1,237	0	4,375	4,962	5	0	5	163	10,962
Middle North Platte Casper	0	0	0	0	0	0	45	0	27	0	0	5	0	0	77
Total	1,014	0	626	210	9	0	10,295	19	15,311	21,549	294	5	203	2,696	52,231

Table 4–32 Cumulative Oil and Gas (including CBM) Direct Impacts to Vegetation by Alternative and Surface Owner

	Proportion of Surface Owner Area Disturbed							
	Alternative 1		Alternative 2A		Alternative 2B		Alternative 3	
Surface Owner	Short-Term (Percent)	Long-Term (Percent)	Short-Term (Percent)	Long-Term (Percent)	Short-Term (Percent)	Long-Term (Percent)	Short-Term (Percent)	Long-Term (Percent)
Buffalo FO	4.04	1.92	4.29	2.17	4.19	2.07	0.19	0.19
Casper FO	0.28	0.27	0.28	0.27	0.28	0.27	0.20	0.20
USFS	4.87	2.65	5.15	2.92	5.04	2.81	0.63	0.63
State	2.65	1.67	2.78	1.80	2.72	1.75	2.58	1.64
Private	4.96	2.89	5.22	3.15	5.11	3.04	2.78	1.90
Total	4.49	2.59	4.73	2.83	4.63	2.72	2.39	1.63

Table 4–33 Cumulative Oil and Gas (including CBM) Direct Impacts to Vegetation by Alternative and Sub-watershed

	Proportion of Sub-watershed Disturbed							
	Alternative 1		Alternative 2A		Alternative 2B		Alternative 3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn	0.06	0.05	0.06	0.07	0.06	0.05	0.06	0.05
Upper Tongue River	3.04	1.74	3.29	1.86	3.18	1.83	2.66	1.56
Middle Fork Powder	0.07	0.06	0.07	0.06	0.07	0.06	0.05	0.05
North Fork Powder	0.03	0.02	0.03	0.02	0.03	0.02	0.00	0.00
Upper Powder River	6.73	3.45	6.98	3.69	6.88	3.66	2.23	1.43
South Fork Powder	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.17
Salt Creek	1.00	0.51	1.07	0.59	1.00	0.57	0.56	0.32
Crazy Woman Creek	3.53	1.59	3.80	2.05	3.65	1.74	1.26	0.62
Clear Creek	4.15	2.19	4.41	2.43	4.33	2.31	2.85	1.54
Middle Powder	4.59	3.03	4.80	3.32	4.83	3.27	2.24	1.91
Little Powder	5.49	3.87	5.66	4.15	5.70	3.94	3.58	2.84
Little Missouri	1.57	1.32	1.88	1.40	1.57	1.37	0.66	0.58
Antelope	8.04	3.78	8.52	4.43	8.24	4.17	3.43	2.02
Dry Fork Cheyenne	0.29	0.27	0.30	0.28	0.29	0.27	0.23	0.22
Upper Cheyenne	2.83	1.87	2.99	2.05	2.97	1.97	1.45	1.23
Lightning Creek	0.78	0.77	0.79	0.78	0.78	0.77	0.74	0.73
Upper Belle Fourche	7.08	4.90	7.60	5.17	7.29	5.06	5.28	3.99
Middle North Platte Casper	0.14	0.12	0.14	0.13	0.14	0.13	0.08	0.08
Total	4.49	2.59	4.73	2.83	4.63	2.72	2.39	1.63

On-going coal mining activities disturb vegetation at a rate of approximately 2,000 acres per year, while 1,850 acres of previously disturbed vegetation is successfully reclaimed on an annual basis. At present, approximately 54,000 acres have been disturbed by coal mining, while 20,200 acres have been successfully reclaimed. An unknown portion of disturbed coal mining area is currently undergoing reclamation, but has not yet met success standards. A similar level of both

new disturbance and reclamation success is expected in the reasonably foreseeable future.

Uranium mining has resulted in the disturbance of approximately 4,400 acres, while sand, gravel, and scoria mining has resulted in the disturbance of approximately 1,200 acres. Agriculture has resulted in impacts to approximately 113,643 acres of lands formally occupied by native vegetation. Agricultural areas are not expected to substantially expand or contract in the foreseeable future. Urban development has resulted in the loss of approximately 4,362 acres of native vegetation. A minor amount of new rural and urban development is expected in the foreseeable future but no estimate of the amount or types of vegetation disturbance has been made. Cumulative impacts to vegetation from roads, railroads, and rural development have not been estimated, except where road impacts are part of existing or proposed oil and gas activities. These road impacts are included in Table 4–32 and Table 4–33.

All non-oil and gas impacts to have resulted in the loss of approximately two percent of the native vegetation in the Project Area. When non-oil and gas impacts are combined with the existing and projected impacts from oil and gas development, approximately 6.5 percent of the vegetation in the Project Area would be in a disturbed state in the short-term, and approximately four percent of the vegetation in the Project Area would be in a disturbed state in the long-term, depending on the alternative selected.

The total acreage affected by CBM development would not be disturbed simultaneously, because Project development would occur over the life of the Project. Some of the disturbed acreage would be reclaimed or would be in the process of being reclaimed when new disturbances are initiated. CBM development is expected to occur at a rate faster than abandonment and reclamation of wells. In the near future (5 to 10 years), the amount of disturbed vegetation is likely to increase, although the anticipated life of coal bed methane wells (12 to 20 years) indicates that reclamation would eventually overtake new well development, resulting in a net decrease in disturbed vegetation over the long-term.

Cumulative effects would also occur to vegetation resources as a result of indirect impacts. One factor is the potential import and spread of noxious weeds around project facilities. Noxious weeds have the ability to displace native vegetation and hinder reclamation efforts. If weed mitigation and preventative procedures were applied to all construction and reclamation practices, the impact of noxious weeds would be minimized.

In areas reclaimed after CBM development, the reclaimed areas often differ substantially from undisturbed areas in terms of vegetation cover. Reclaimed areas may not serve ecosystem functions presently served by undisturbed vegetation communities, particularly in the short term, when species composition, shrub cover, and other environmental factors would likely be different. Establishment of noxious weeds and alteration of vegetation along drainages and reclaimed areas has the potential to alter vegetation type distribution. As a result, alteration of biodiversity may occur due to the overall effects of the Project on vegetation.

Wetland/Riparian Areas

Potential effects to wetlands and riparian areas are similar to those for vegetation. In general, efforts would be made to prevent effects to wetlands and riparian areas by locating roads and facilities outside of these sensitive resources. Well pads would not be located in wetlands or riparian areas. Other facilities, particularly those of a linear nature, such as transmission lines and pipelines, would cross wetlands and riparian areas where routes that avoid these areas are not available.

Direct effects to wetlands and riparian areas would occur from the disturbance or removal of vegetation and soils in these areas resulting from the construction of transmission lines, pipelines, roads, and other facilities. Short-term effects would occur where vegetated areas are disturbed but later reclaimed within one to three years of the initial disturbance. Long-term effects would occur where roads or other semi-permanent facilities result in loss of vegetation and prevent reclamation for the life of the Project. These areas would be reclaimed during the abandonment phase, although not all roads may be reclaimed. Restoration of wetland and riparian area form and function can be difficult and may require an extended period of time. In other cases where impacts are minimal and limited in scale, restoration may occur quickly due to the availability of more water and better soils than are present in the Project Area in general.

Indirect effects to wetlands and riparian areas would occur as a result of activities other than the direct disturbance or removal of vegetation and soils. Possible indirect effects may include: 1) an increase in the potential for the spread of noxious weeds and displacement of native vegetation, due to ground disturbance in the Project Area; 2) alteration of wetland distribution and riparian area function due to changes in volume and rate of surface water flows, particularly changes in stream flow from intermittent to perennial; 3) alteration of ecosystem biodiversity due to changes in plant species composition, abundance, and distribution; and 4) changes in wildlife abundance and distribution due to changes in wetlands and riparian areas.

Alternative 1

Direct Effects

Approximately 7,306 acres (2.9 percent of the wetland/riparian areas in the Project Area) of wetland/riparian vegetation would be directly disturbed (Table 4–16 and Table 4–17) in the short-term. Direct disturbance would occur across five wetland/riparian vegetation types, including forested riparian, herbaceous riparian, shrubby riparian, water, and wet meadow. Direct disturbance of wetland/riparian vegetation would occur in ten of the 18 sub-watersheds within the Project Area (Table 4–17).

Long-term disturbance would still occur in the same vegetation types as would short-term disturbance, but the total area that remained disturbed would be less (3,534 acres or 1.4 percent of the wetland/riparian areas in the Project Area). Total long-term disturbance by land ownership type is shown in Table 4–18. Long-term disturbance would also occur in ten of the 18 sub-watersheds, but again in

lesser amounts. The extent of long-term disturbance in each sub-watershed is shown in Table 4–19. Alternative 1 would result in lower short- and long-term direct impacts to wetland/riparian areas than Alternatives 2A or 2B, but greater impacts than Alternative 3. This difference in impacts is primarily due to the different ratios of the various water handling options that would be applied under each alternative.

Produced water from CBM wells would be gathered for discharge at outfalls. Outfalls may feed into small stock reservoirs, constructed infiltration basins, or other facilities before the outflows reach surface drainages. The additional surface flows of water would directly result in the disturbance or removal of vegetation and soils. The extent of disturbance is dependent on the location chosen for discharge points, the vegetation and soils that occur downstream of the discharge, and the amount of increase in surface flows. Direct disturbance caused by surface discharge of CBM water would occur in ten of the 18 sub-watersheds within the analysis area (Tables 2-6 and 2-7).

No direct effects on wetland/riparian areas would occur as a result of the creation of containment reservoirs because they would be constructed in upland sites away from wetland/riparian areas. Infiltration reservoirs would be constructed on bottomland or upland sites. Where these reservoirs are constructed in bottomland sites, wetland/riparian areas may be impacted. The extent of these impacts cannot currently be quantified because the locations of these reservoirs have not been determined. Containment reservoirs would be constructed in upland areas, away from drainages, floodplains, and gravelly terraces, and would not be constructed as flow-through impoundments. Atomizers would be located on towers situated on floating islands in the central portions of the reservoir. Spray from these units would be directed above the water surface only, so that the land surface near the reservoir would be unaffected.

No direct effects on wetland/riparian areas would occur as a result of the creation of land application disposal (LAD) sites and/or injection facilities. These sites would be placed in upland areas away from drainages and floodplains. Water would be applied at agronomic rates at LAD sites so that there would be no run-off or infiltration of applied water that could reach surface drainages.

Following the life of the Project, facilities would be removed and their disturbed areas would be reclaimed and returned to pre-project uses. This restoration would typically include replacing salvaged topsoil, re-grading, and reseeding disturbed areas. Efforts directed toward successful reclamation of all Project disturbances would be continued until reclamation is successful.

Indirect Effects

Implementation of Alternative 1 would increase the potential for the occurrence of indirect effects to wetland/riparian areas within the Project Area. Indirect effects to wetland/riparian areas would occur in ten of the eighteen sub-watersheds. Ten out of eighteen sub-watersheds would also be indirectly affected specifically due to water discharge.

Disturbances associated with the construction of well pads, compressor stations, roads, and other facilities would provide opportunities for the invasion and establishment of noxious weeds. Noxious weeds tend to be aggressive invaders of disturbed areas, often displacing native wetland/riparian vegetation. The extent of these invasions is difficult to predict, and would be determined by many factors, including the extent of disturbed areas, the extent of existing weed infestations that would provide a seed source, the amount of equipment movement for areas infested with weeds to areas not yet infested, and the time lag between the end of disturbance and the successful completion of reclamation.

Surface discharge of produced water from CBM wells has the potential to alter vegetation patterns in areas downstream of discharge points. The shift in surface water flows would provide another type of disturbance that could be exploited by noxious weed species, as well as providing a means for the spread of noxious weeds. Noxious weeds and other aggressive species could come to dominate disturbed wetland/riparian areas, potentially reducing biodiversity in these situations.

The function of wetland and riparian areas would be altered due to changes in volume and rate of surface water flows. The increased availability of water along normally dry stream channels could cause an increase in the extent of riparian and wetland vegetation, as well as changes in stream flow from intermittent to perennial. The extent of these changes is dependent on the locations chosen for discharge points, and on the existing vegetation and soils downstream of these points.

Depending on the quality and volume of produced water, other changes in wetland/riparian vegetation may occur. In areas where the water table (i.e., shallow aquifer) rises to the surface, some plant species would not be able to grow due to saturation of the soil, thus altering the species composition of affected areas. Where continuous inundation occurs in forested riparian areas, cottonwood seedlings would not be able to become established. In other areas where the water table rises to or near the surface, cottonwood seedling establishment may increase due to increased shallow water availability.

Groundwater pumping related to CBM production is generally not expected to result in a lowered water table in shallow alluvial aquifers (see groundwater section). In some isolated locations, particularly around the edges of the Powder River Basin where the cover of the Wasatch Formation over the coal beds is thin, the groundwater table may drop. Where this drop coincides with existing wetland/riparian areas and is substantial, some wetland/riparian vegetation may be lost. The occurrence of this impact is expected to be minimal.

The quality of produced water is regulated by the NPDES permit system administered by the Wyoming DEQ. Although produced water in some areas would be of low quality, this water would be disposed of in a manner that would prevent impacts to wetland/riparian vegetation. Water that is disposed of by surface discharge or infiltration would meet DEQ water quality standards that are designed to protect aquatic life, livestock, wildlife, and other applicable water uses (such as agricultural irrigation). Because of these standards, water quality of produced

water from CBM wells is not expected to have any effect on wetland/riparian areas.

There would be no indirect effects to wetland/riparian areas due to the creation of containment reservoirs, LAD sites, and/or injection wells. These sites would be placed in upland areas away from drainages and floodplains.

Alteration of biodiversity would occur due to changes in plant species composition, abundance, and distribution. Large, contiguous areas of wetland/riparian vegetation would be fragmented by the construction of roads, pipeline corridors, and other linear facilities if such areas must be disturbed. Disturbance followed by reclamation would alter the species composition of reclaimed areas when compared with undisturbed areas by replacing diverse native communities with communities consisting of a few favored reclamation species. The increase of surface water flows in riparian and wetland areas may also create an increase in biodiversity within and adjacent to disturbed areas because wetland and riparian areas tend to support a greater number of species than do adjacent uplands.

Wetland/riparian areas are important to wildlife species dependent on these types as habitat. Where the native vegetation provides an essential component of wildlife habitat, these shifts in vegetation pattern would result in decreased habitat quality for wildlife. Some of these changes in wetland/riparian vegetation would occur in areas that have been specifically identified as being important to the conservation of biological diversity.

Alternative 1 would result in potentially greater indirect impacts to wetland/riparian areas than would Alternatives 2A, 2B, or 3, because of the greater amount of surface discharge of produced water. Water that is discharged to surface drainages has a greater chance of affecting wetlands than water that is contained in reservoirs, applied directly to vegetation in upland situations, or injected. These impacts are difficult to quantify for many reasons, including variables related to the number of wells discharging into each drainage, the amount of water produced by each well, the amount of evaporation and infiltration that occurs between discharge point and wetland/riparian areas, the ability of the shallow alluvial aquifer to absorb water inputs without affecting water levels in wetland/riparian areas, and the ability of wetland/riparian vegetation to adapt to increased water availability.

Alternatives 2A and 2B

Direct Effects

Under Alternative 2, direct disturbance would be similar to Alternative 1. Within Alternative 2, two different ratios of the various water handling options (Alternatives 2A and 2B) have been analyzed. All disturbance associated with these alternatives would occur in the same vegetation types, land ownerships, and subwatersheds as Alternative 1. Table 4–20 and Table 4–24 show the direct, short-term disturbance to wetland/riparian areas by surface owner for Alternatives 2A and 2B, respectively. Table 4–21 and Table 4–25 show the direct, long-term disturbance to wetland/riparian areas by surface owner for Alternatives 2A and 2B,

respectively. Table 4–22 and Table 4–26 show the direct, short-term disturbance to wetland/riparian areas by sub-watershed for Alternatives 2A and 2B, respectively. Table 4–23 and Table 4–27 show the direct, long-term disturbance to wetland/riparian areas by sub-watershed for Alternatives 2A and 2B, respectively. Total disturbance to wetland/riparian areas under Alternative 2A would encompass 7,707 acres (3.1 percent of the wetland/riparian areas in the Project Area) in the short-term and 3,935 acres (1.6 percent of the wetland/riparian areas in the Project Area) in the long-term. Total disturbance to wetland/riparian areas under Alternative 2B would encompass 7,386 acres (2.9 percent of the wetland/riparian areas in the Project Area) in the short-term and 3,614 acres (1.4 percent of the wetland/riparian areas in the Project Area) in the long-term.

The primary difference between Alternatives 1, 2A, and 2B, in terms of direct disturbance of wetland/riparian vegetation, would be in the relative proportion of disturbance caused by the different types of water disposal methods. Water handling options would directly disturb vegetation in ten of the 18 sub-watersheds within the Project Area (Tables 2-23 to 2-26). Alternative 2A would result in the greatest short- and long-term direct impacts to wetland/riparian areas when compared with Alternatives 1, 2B, and 3, while Alternative 2B would have less direct impact than Alternative 2A and more than Alternatives 1 and 3. These differences in impacts are primarily due to the different ratios of the various water handling options that would be applied under each alternative. There would be no differences in the effects of containment, LAD, or injection because these methods are only applied in upland locations, not in wetland/riparian areas. There would be fewer surface discharge locations and more infiltration reservoirs under Alternatives 2A and 2B, when compared with Alternative 1. This difference would result in greater impacts to wetland/riparian areas where these reservoirs are constructed in bottomland locations. Alternative 2A has a greater proportion of infiltration reservoirs than Alternative 2B, meaning that more wetland/riparian areas would potentially be impacted by Alternative 2A than by Alternative 2B.

Indirect Effects

Similar indirect impacts would occur to wetland/riparian areas as described under Alternative 1, although the amount of impact would be different. Both Alternative 2A and 2B would result in potentially less indirect impact to wetland/riparian areas than would Alternatives 1, but more than Alternative 3. Impacts would be reduced because of the smaller amount of surface discharge of produced water. Alternative 2B would result in the surface discharge of substantially more water than would Alternative 2A, although the total amount would still be substantially less than for Alternative 1.

Alternative 3

Direct Effects

Approximately 6,678 acres (2.7 percent of the wetland/riparian areas in the Project Area) of wetland/riparian vegetation would be directly disturbed (Table 4–28) in the short-term. Direct disturbance would occur across four wetland/riparian vegetation types, including forested riparian, shrubby riparian, water, and wet meadow. Direct short-term disturbance of wetland/riparian vegeta-

tion would occur in nine of the 18 sub-watersheds within the Project Area (Table 4–29).

Long-term disturbance would still occur in the same four vegetation types as would short-term disturbance, but the total area that remained disturbed would be less (3,202 acres or 1.3 percent of the wetland/riparian areas in the Project Area). Total long-term disturbance by land ownership type is shown in Table 4–30. Long-term disturbance would also occur in nine of the 18 sub-watersheds, but again in lesser amounts. The extent of long-term disturbance in each sub-watershed is shown in Table 4–31. Alternative 3 would result in the lowest level of short- and long-term direct impacts to wetland/riparian areas compared with Alternatives 1, 2A, or 2B. This difference in impacts is primarily due to the smaller number of wells that would be drilled under this alternative. The proportion of different water handling methods under Alternative 3 would be most similar to Alternative 1 and substantially different than Alternatives 2A and 2B (Tables 2-32 and 2-33). The greater proportion of surface discharge would potentially result in greater effects to wetland/riparian areas; however, the total potential impacts to wetland/riparian areas would be less than the three other alternatives because the total number of wells utilizing surface discharge as the water handling method would be less.

Indirect Effects

Implementation of Alternative 3 would increase the potential for the occurrence of indirect effects to wetland/riparian areas within the Project Area, although to a lesser degree than Alternatives 1 and 2. Indirect effects to wetland/riparian areas would occur in nine of the 18 sub-watersheds. Ten out of eighteen sub-watersheds would also be indirectly affected specifically due to water discharge.

No new mitigation measures (such as those that would be applied under Alternatives 1, 2A, and 2B) would be applied to wetland/riparian areas under Alternative 3 because there would be no federal action. Existing regulations that protect wetland/riparian areas, such as the Clean Water Act, would continue to be enforced. Because the additional mitigation measures discussed under the other alternatives would only apply to new wells subject to federal action and not to state or private wells, the potential for indirect effects to wetland/riparian areas from state and private wells would not change under Alternative 3. Only the potential indirect effects from federal wells would be removed.

Cumulative Effects

Implementation of the alternatives would contribute to cumulative effects on wetland/riparian areas in the Project Area. Development in wetland and riparian habitats would generally be avoided within the Project Area. Cumulative effects to wetland/riparian vegetation are included in the total effects to vegetation as shown in Table 4–32 and Table 4–33. Much of the discussion of cumulative effects to vegetation is also relevant to wetland/riparian areas. Coal, uranium, sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban development are likely to have some effect on wetland/riparian areas. Projects generally attempt to avoid wetland/riparian areas,

but some types of projects, especially those that are linear in nature, cannot avoid all impacts to these sensitive resources.

As with vegetation, cumulative effects would occur to wetland/riparian resources as a result of indirect impacts. Certain types of development, including CBM development, would have the potential to alter the hydrology of riparian and wetland areas, possibly to the extent that habitat currently suitable for some plant and wildlife species would become unsuitable. Following closure and reclamation of wells, alteration of surface hydrology would cease and water regimes would return to existing conditions. The presence of noxious weeds may increase, thus displacing native vegetation and hindering reclamation efforts. As a result, changes in wetland and riparian area distribution, function, and biodiversity may occur.

Wildlife

The principal effects to terrestrial wildlife likely to be associated with the Project may include: 1) disturbance effects (including raptors, sage grouse, sharp-tailed grouse, deer, elk, antelope, and waterfowl) by human activity; 2) the loss of certain habitats, particularly big game crucial winter ranges; 3) habitat fragmentation (particularly through construction of roads and well pads); 4), the introduction of new perches for raptors and thus potential increase in local predation rates on other wildlife species; 5) an increase in hunting pressure; 6) an increase in wildlife harassment; and 7) Project-induced increases in mortality (e.g., poaching, trapping, poisoning, roadkills, raptor collision, raptor electrocution). The magnitude of effects to wildlife resources would depend on a number of factors including the recommended and required mitigation measures.

Direct disturbance of wildlife habitats would occur in each sub-watershed and under each alternative. In an effort to return habitats to wildlife use, unused portions of well sites would be reclaimed during the production phase. Following the end of the production phase, well field and ancillary facilities would be removed and disturbed areas reclaimed. Seed mixes approved by the appropriate agency, many of which are intended to be beneficial to wildlife species, would be used to revegetate abandoned well pads and areas occupied by ancillary facilities. The amount of time these lands are unsuitable as wildlife habitats is variable and may depend on one or more of the following: productive well life-span, mitigation success, reclamation techniques, and local weather conditions. Reclamation of habitats dominated by grasses and forbs is expected to be successful within several years; habitats dominated by shrubs and trees may take 8 to 20 years or more to successfully re-establish. Consequently, the disturbance of forest and shrub habitats would represent a long-term loss beyond the end of the production phase to those species that depend on such vegetation for forage or shelter. In addition, an unknown percentage of roads would not be reclaimed, resulting in permanent loss of wildlife habitats.

Indirect effects, including the displacement of wildlife, would occur in varying degrees during construction, production, and reclamation phases of the Project. In response to the increased levels of human activity, equipment operation, vehicular traffic, and noise associated with all phases of the Project, wildlife would

avoid areas of these activities and utilize other locations. This avoidance would result in the under-utilization of otherwise suitable habitats; therefore the value of these habitats would be diminished. The displacement of wildlife from disturbed areas may also lead to the over-utilization of suitable habitats, increasing competition for limited resources in these areas and potentially leading to increased mortality. Additionally, wildlife distribution patterns would be altered. The degree of habitat avoidance would vary among species and among individuals of any particular species.

Mitigation measures expected to eliminate or minimize potential effects to wildlife species are provided at the end of this chapter and/or in Chapter 5 and Appendices C and D.

Alternative 1

Water handling methods under this Alternative would affect 33,808 acres in ten of the 18 watersheds within the Project Area. In total, Alternative 1 would include 213,115 and 109,922 acres of short- and long-term disturbance, respectively. In comparison, these values are less than estimates for Alternatives 2A and 2B, and more than for Alternative 3.

There are several options for handling CBM produced waters including treated surface discharge, untreated surface discharge, infiltration, impoundment, LAD, and injection. Any of these options would result in additional short- and long-term disturbance to wildlife habitats in the Project Area. Because the location of these facilities is not known, the wildlife habitats to be affected are also unknown. All of the following water handling options may directly disturb wildlife habitats within the Project Area.

Where surface discharge is selected as the water handling option, produced water from CBM wells would be gathered for surface discharge, feeding a small flow-through stock reservoir or discharging directly to a nearby surface drainage. Surface discharge associated with Alternative 1 would cause direct disturbance to 7,296 acres of wildlife habitats.

Where impoundment (i.e., no surface discharge and minimal infiltration) is selected as the water handling option, large containment reservoirs would be constructed. Impoundment associated with Alternative 1 would cause direct disturbance to 6,293 acres of wildlife habitats.

Where LAD is selected as the water handling option, disposal of CBM produced water would likely be accomplished using a disposal-rest rotation cycle consisting of disposal, soil amendment, rest, disposal, etc., until the limitations of repeated soil amendments are reached and the site reclaimed. Direct affects to wildlife habitats at LAD sites would result in direct disturbance of 1,780 acres.

Where infiltration is selected as the water handling option, infiltration impoundments of varying sizes would be constructed. Produced water from CBM wells would be gathered in each impoundment. Bore holes and trench-type excavations would enhance infiltration, and evaporation would be enhanced through the use

of atomizers placed on towers situated on floating islands. Direct affects to wildlife habitats at infiltration sites would result in direct disturbance of 14,566 acres.

Where injection is selected as the water handling option, produced water from CBM wells would be gathered for injection at an injection well facility site. Direct affects to wildlife habitats at injection sites would result in direct disturbance of 3,873 acres.

Terrestrial Species

Big Game

The following text presents potential direct and indirect effects to big game within the Project Area. This information includes the identification of effect types and their potential effects to big game. Much of the following information is restricted to a qualitative analysis due to the lack of data relevant to the potential effect types and species. As an exception, existing habitat and range data were used to develop potential disturbance acres for each big game species by surface owner and sub-watershed.

Pronghorn

Direct and Indirect Effects

Direct and indirect effects to pronghorn and their ranges may occur as the result of activities proposed under Alternative 1. Direct effects resulting from construction of proposed CBM wells, compressors, non-CBM wells, and associated water handling methods were estimated by applying facility-specific disturbance factors to the proposed number of each facility type. These facility-specific disturbances were then summed and used to estimate the potential number of acres disturbed for each range type. Estimated disturbances to each range type are presented by surface owner and sub-watershed in Table 4–34 and Table 4–35. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–36).

Table 4–34 Direct Short-term and Long-term Effects to Pronghorn Ranges by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	BFO		BFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Severe Winter	0	0	0	0	39	32	0	0	17	14	14	46
Crucial Winter	0	0	0	0	0	0	0	0	0	0	0	0
Yearlong												
Winter	1,532	582	0	0	0	0	621	261	4,860	2,205	13,919	3,048
Winter Yearlong	4,359	1,620	17	14	1,135	491	2,693	1,122	57,572	22,609	143,025	25,856
Yearlong	13,330	5,099	39	32	9,199	3,734	12,843	4,797	114,137	43,270	325,388	56,932
Spring, Summer, Fall	102	41	17	14	0	0	11	9	969	387	2,309	451
Total	19,323	7,342	73	60	10,373	4,257	16,168	6,189	177,555	68,485	484,655	86,333

Habitat Disturbance

There are approximately seven million acres of pronghorn range in the Project Area. Direct disturbance to pronghorn ranges would result from construction of well pads, compressor stations, associated utility corridors, access roads and water handling features, as outlined in Chapter 2 of this document. Disturbance to pronghorn ranges from project activities would result in the localized reduction of available forage and increased fragmentation of existing contiguous habitats. The concentration of potential disturbance would be variable but is not expected to result in the alteration of seasonal habitat use or herd movements of pronghorn within the Project Area.

Approximately 75,113 acres of yearlong range would be disturbed during the life of the project (e.g., long-term). This total represents the single largest total acreage for the six types of pronghorn ranges that would be disturbed under this alternative. The single largest percentage of long-term effects to pronghorn range would occur in winter range, where approximately 3,992 acres of a total 156,961 acres (three percent) would be disturbed. Pronghorn winter range occurs in the Upper, Middle, and Lower Powder River sub-watersheds and is typically dominated by sagebrush shrublands, coniferous forests, and agricultural lands. Approximately two percent of winter-yearlong and yearlong ranges would be disturbed during the life of the project. These pronghorn ranges occur throughout most of the sub-watersheds in the Project Area and are typically dominated by short- and mixed-grass prairie and sagebrush shrubland habitats. Pronghorn crucial winter-yearlong range (145 acres in Project Area) is restricted to the Middle North Platte River sub-watershed and would not be disturbed by actions proposed under Alternative 1. The loss of suitable pronghorn habitats would not likely result in adverse effects to seasonal habitat use or herd movements or condition because of the availability of suitable habitat throughout the Project Area.

Table 4–35 Direct Short-term and Long-term Effects to Pronghorn Ranges by Sub-watershed – Alternative 1

	Pronghorn Ranges (acres)													
	Severe		Crucial		Winter		Winter Yearlong		Yearlong		Spring, Summer, Fall		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	1,396	646	16,047	7,591	0	0	17,444	8,238
Middle Fork Powder	0	0	0	0	0	0	44	36	6	5	28	23	78	64
North Fork Powder	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Upper Powder	0	0	0	0	6,495	2,958	29,752	13,446	39,725	17,810	6	5	75,978	34,219
South Fork Powder	0	0	0	0	0	0	0	0	17	14	0	0	17	14
Salt Creek	0	0	0	0	0	0	414	161	215	109	28	23	657	293
Crazy Woman Creek	0	0	0	0	0	0	6	5	18,621	7,958	0	0	18,627	7,963
Clear Creek	0	0	0	0	0	0	3,139	1,543	16,222	7,972	0	0	19,360	9,514
Middle Powder River	0	0	0	0	297	153	0	0	4,697	2,228	1,187	551	6,181	2,932
Little Powder River	0	0	0	0	1,164	881	10,782	5,281	15,706	8,007	0	0	27,651	14,168
Little Missouri	0	0	0	0	0	0	17	14	435	356	0	0	452	370
Antelope Creek	28	23	0	0	0	0	2,165	817	43,218	16,393	0	0	45,411	17,233
Dry Fork Cheyenne	28	23	0	0	0	0	50	41	193	158	0	0	271	222
Upper Cheyenne	0	0	0	0	0	0	1,613	755	2,178	1,061	0	0	3,792	1,817
Lightning Creek	0	0	0	0	0	0	22	18	248	203	0	0	270	221
Upper Belle Fourche	0	0	0	0	0	0	26,339	13,085	10,159	5,192	0	0	36,498	18,277
Middle North Platte Casper	0	0	0	0	0	0	148	122	61	50	0	0	209	172
Total	56	46	0	0	7,956	3,992	75,887	35,970	167,755	75,113	1,249	602	252,903	115,723

Table 4–36 Pronghorn Water Handling Disturbance Acres by Sub-watershed — Alternative 1

	Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	186	224	2,280	2,747	2,466	2,972
Middle Fork Powder	0	0	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	1,362	892	5,861	3,839	7,741	5,070	14,964	9,801
South Fork Powder	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	12	11	6	5	18	16
Crazy Woman Creek	0	0	0	0	0	0	2,922	2,104	2,922	2,104
Clear Creek	0	0	0	0	556	651	2,870	3,358	3,426	4,008
Middle Powder	182	149	46	38	0	0	655	537	883	724
Little Powder	0	0	18	15	846	694	1,128	925	1,992	1,633
Little Missouri	0	0	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	77	70	1,567	1,434	1,644	1,504
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	242	221	291	266	533	488
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	4,225	4,394	1,651	1,717	5,876	6,111
Middle N Platte Casper	0	0	0	0	0	0	0	0	0	0
Total	182	149	1,426	945	12,005	10,104	21,111	18,164	34,724	29,362

These estimates of range disturbance apply to the entire life of the project. The amount of range disturbance at any one time during project implementation would be less than these estimates, because as new areas are disturbed by development, other areas would be undergoing reclamation following development that is completed.

Habitat Fragmentation

Habitat fragmentation may occur in some suitable pronghorn habitats from the construction of project-related facilities (e.g., access roads). The extent of potential fragmentation is unknown because the precise location of project-related facilities is undetermined at this time. The potential effects of habitat fragmentation are dependent upon several factors, including current habitat condition and fragmentation, proximity of additional suitable habitats, degree of proposed disturbance and fragmentation, and local population size. Because these determinant factors are largely unknown at this time, it is difficult to quantify the effects of additional fragmentation. Pronghorn may avoid habitat that is otherwise suitable, depending on the extent of the fragmentation. The effects of potential fragmentation would not likely adversely affect the pronghorn because of the widespread occurrence and availability of suitable habitats throughout the Project Area.

Vehicle Collisions

Increased human activity as the result of project implementation may have several effects on pronghorn. Increased vehicle traffic is anticipated in association with the construction, production, and reclamation/abandonment phases of the Project. Quantifiable effects to pronghorn as the result of increased vehicle traffic are not available; however, the potential for vehicle collisions with pronghorn is expected to be directly correlated with the volume of traffic. Project-related traffic volumes are expected to be greatest during the construction phase and gradually diminish in the production and reclamation/abandonment phases.

Human Disturbance

Pronghorn would potentially be temporarily displaced from suitable habitats in areas of concentrated human activity. Displacement would likely be dependent on the activity duration and intensity (i.e., drill rig operations versus survey work). When displaced, pronghorn individuals would move to other adjacent suitable habitats but may encounter competition for resources. Big game sensitivity to human disturbance is difficult to quantify, and, therefore, the potential distance and duration of displacement is not known at this time. Displacement due to concentrations of human activity is not expected to cause serious detrimental effects to pronghorn because human disturbance would likely be limited temporarily and spatially, and suitable undisturbed pronghorn habitats are available and widespread throughout the Project Area.

Diversion from Public to Privately Owned Lands

Project actions are proposed for lands owned by public agencies (e.g., BLM and USFS), the State of Wyoming, and individual private owners. The majority of human activity associated with the Project would occur on privately owned lands, with relatively little development of publicly owned lands. Pronghorn and other wildlife utilize suitable habitats despite ownership boundaries. No known distribution information relevant to land ownership is available for pronghorn. It is possible in areas that receive relatively high hunting pressure on publicly owned lands, that pronghorn may prefer suitable habitats on privately owned lands and temporarily avoid otherwise suitable habitats on publicly owned lands. Under such an assumption and if project activities occur in sufficient densities on privately owned lands, some pronghorn may not prefer habitats on privately owned lands and thus remain on publicly owned lands. Issues relating to pronghorn and other wildlife occurrence patterns on lands of different ownership (e.g., privately owned versus publicly owned) and the potential effects from project activities are speculative due to the undetermined density and local pattern of project activities, including the effects of new access roads. The effects from new access roads is difficult to quantify because road densities and lengths are dependent upon specific facility locations, which are undetermined at this time.

Noise and Dust

Elevated noise levels associated with increased human activity and facility operations may affect pronghorn. Elevated noise levels may deter pronghorn from utilizing localized areas of suitable habitat. The effects of project-related noise levels to pronghorn would depend upon the occurrence pattern and intensity of produced noise. Pronghorn responses may vary from tolerance to avoidance of affected habitats. Due to the availability of alternate suitable pronghorn habitats throughout much of the Project Area, localized elevated noise levels are not expected to result in decreased condition or an increased mortality rate of pronghorn in the Project Area.

The generation and deposition of dust on suitable pronghorn forage may occur along existing and new roads within the Project Area. The accumulation of dust on suitable pronghorn forage would likely be limited to habitats immediately adjacent to unimproved roads and represent a relatively small fraction of the total available forage within a typical pronghorn range. The loss of potential forage due to the accumulation of dust would not affect the survivability or condition of pronghorn individuals or populations.

Water Handling

The proportion of different water handling methods varies across sub-watersheds (refer to Chapter 2 for details). The number of proposed CBM wells by alternative can be used to estimate the associated disturbance to big game ranges by water handling methods. Under Alternative 1, the total number of proposed CBM wells within pronghorn ranges is 34,724, of which more than 21,111 wells (60 percent) occur in pronghorn yearlong range. Approximately 32,685 acres would be disturbed by water handling methods under this alternative (Table 4–36).

Construction of water handling facilities would likely occur in upland situations; however, the exact location and habitat type for these facilities is currently undetermined. Because sagebrush shrublands and short- and mixed-grass habitats are the most common and widely distributed habitat types within the Project Area, it is assumed these habitat types would experience the majority of disturbance associated with the construction of water handling facilities (refer to the vegetation section of this chapter). The destruction of suitable pronghorn habitats following the construction of various water handling facilities may have both positive and negative effects to pronghorn. The loss of suitable habitats due to the construction of water handling facilities would not limit the occurrence or availability of these habitats over the home range of individual pronghorn, which can vary between 407 and 5,683 acres (Clark and Stromberg 1987). The relative amount of habitat loss would be outweighed by the availability and widespread occurrence of suitable habitat throughout the Project Area. The operation of water handling facilities under this alternative may provide pronghorn and other wildlife with additional drinking water resources and may increase the amount of forage available in wetland and riparian areas that expand in response to surface discharge of produced water. As fully described in Chapter 2, water quality is strictly controlled by the NPDES permitting process. Water that may be available to wildlife and livestock would meet all NPDES permitting requirements and, therefore, would not be expected to be harmful to pronghorn. The distribution of existing water resources combined with the distribution of new water handling facilities would not result in concentrations of big game or other wildlife to the extent that it would be detrimental to wildlife (e.g., disease vectors) or wildlife habitats. Although water handling facilities would not be specifically intended for big game or wildlife use, these facilities would be designed and constructed to avoid potential entrapment or drowning risks.

White-tailed Deer

Direct and Indirect Effects

Direct and indirect effects to white-tailed deer and their ranges may occur as the result of activities proposed under Alternative 1. Quantification of potential direct effects resulting from proposed CBM wells, compressors, non-CBM wells, and associated water handling methods were estimated by applying facility-specific disturbance factors to the proposed number of each facility type. These facility-specific disturbances were then summed and used to estimate the potential number of acres disturbed for each range type. Estimated disturbances to each range are presented by surface owner and sub-watershed in Table 4–37 and Table 4–38, respectively. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–39).

Table 4–37 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	609	246	0	0	116	59	1,837	669	13,516	5,340	16,078	6,314
Winter Yearlong	39	32		0	0	0	0	0	0	32	78	64
Total	648	278	0	0	116	59	1,837	669	13,516	5,372	16,156	6,378

Table 4–38 Direct Short-term and Long-term Effects To White-tailed Deer Ranges by Sub-watershed — Alternative 1

	White-tailed Deer Ranges					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	0	0	6,339	2,983	6,339	2,983
Middle Fork Powder River	0	0	17	14	17	14
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	0	0	4,089	1,821	4,089	1,821
South Fork Powder River	0	0	6	5	6	5
Salt Creek	0	0	0	0	0	0
Crazy Woman Creek	0	0	1,013	428	1,013	428
Clear Creek	0	0	5,033	2,433	5,033	2,433
Middle Powder River	39	32	107	53	145	84
Little Powder River	0	0	1,834	1,157	1,834	1,157
Little Missouri River	0	0	0	0	0	0
Antelope Creek	0	0	250	98	250	98
Dry Fork Cheyenne River	0	0	11	9	11	9
Upper Cheyenne River	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche River	0	0	180	115	180	115
Middle North Platte Casper	0	0	0	0	0	0
Total	39	32	18,895	9,129	18,933	9,160

Table 4–39 White-tailed Deer Water Handling Disturbance Acres by Sub-watershed — Alternative 1

	Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0
Upper Tongue River	863	1040	863	1,040
Middle Fork Powder	0	0	0	0
North Fork Powder	0	0	0	0
Upper Powder River	806	528	806	528
South Fork Powder	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	156	112	156	112
Clear Creek	881	1,031	881	1,031
Middle Powder	18	15	18	15
Little Powder	72	59	72	59
Little Missouri	0	0	0	0
Antelope	9	8	9	8
Dry Fork Cheyenne	0	0	0	0
Upper Cheyenne	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche	19	20	19	20
Middle N Platte Casper	0	0	0	0
Total	2,824	2,813	2,824	2,813

Habitat Disturbance

There are approximately 765,647 acres of white-tailed deer range in the Project Area. Direct disturbance to white-tailed deer ranges would result from construction of well pads, compressor stations, associated utility corridors, access roads and water handling features, as outlined in Chapter 2 of this document. Disturbance to white-tailed deer ranges from Project activities would result in the localized reduction of available forage. The concentration of potential disturbance would be variable but is not expected to result in the alteration of seasonal habitat use or herd movements of white-tailed deer within the Project Area.

An estimated 9,160 acres of white-tailed deer winter yearlong and yearlong ranges would be directly disturbed under this alternative. Approximately 9,129 acres of yearlong range would be disturbed during the life of the Project (e.g., long-term), accounting for approximately 99 percent of the total disturbance to white-tailed deer ranges in the Project Area. White-tailed deer yearlong range occurs in nearly all of the sub-watersheds included within the Project Area. White-tailed deer yearlong range is typically associated with stream and river bottoms and dominated by wet meadow, and short- and mixed-grass prairie. Less than one percent of white-tailed winter yearlong range would be disturbed under this alternative. This range occurs in the Middle Powder River sub-watershed and is dominated by short- and mixed-grass prairie, coniferous forest, and wet meadow. No white-tailed deer crucial winter range was identified within the Project Area. The total estimate of long-term disturbance to white-tailed deer ranges

is 9,160 acres, or approximately 14 percent of the total available white-tailed deer range within the Project Area. The loss of suitable white-tailed deer habitats would not likely result in adverse effects to seasonal habitat use, herd movements or herd condition because of the availability of suitable habitat throughout the Project Area.

These estimates of range disturbance include the entire life of the Project. The amount of range disturbance at any one time during project implementation would be less than these estimates, due to the phased nature of development (i.e., as new areas are disturbed by development, other areas would be undergoing reclamation).

Habitat Fragmentation

Habitat fragmentation may occur in some suitable white-tailed deer habitats from the construction of project-related facilities (e.g., access roads). The intensity of potential fragmentation is unknown because the precise location of project facilities is undetermined at this time. The potential effects of habitat fragmentation are dependent upon several factors, including current habitat condition and fragmentation, proximity of additional suitable habitats, degree of proposed disturbance and fragmentation, and local population size. Because these determinant factors are largely unknown, it is difficult to quantify the effects of additional fragmentation. White-tailed deer may avoid habitat that is otherwise suitable, depending on the extent of fragmentation.

Vehicle Collisions

Increased vehicle traffic within the Project Area would likely result in an increased frequency of vehicle collisions with big game and other wildlife. Quantifiable effects to white-tailed deer as the result of increased vehicle traffic are not available; however, the potential for vehicle collisions with white-tailed would be correlated with the volume and frequency of vehicle traffic. Project-related traffic volumes are expected to be greatest during the construction phase and gradually diminish in the production and reclamation/abandonment phases.

Human Disturbance

White-tailed deer would potentially be temporarily displaced from suitable habitats in areas of concentrated human activity. Displacement would likely be dependent on the activity duration and intensity (i.e., drill rig operations versus survey work). When displaced, white-tailed deer would move to other adjacent suitable habitats. Big game sensitivity to human disturbance is difficult to quantify, nonetheless, compared to other big game species, white-tailed deer are less sensitive to temporary or short-term human activities, and therefore, the potential distance and duration of displacement is expected to be more than other big game species. Displacement due to concentrations of human activity are not expected to cause detrimental effects to white-tailed deer because human disturbance would likely be limited temporarily and spatially, and suitable white-tailed deer habitats are available.

Diversion from Public to Privately Owned Lands

Project actions are proposed for lands owned by public agencies (e.g., BLM and USFS), State of Wyoming, and individual private owners. The majority of human activity associated with the Project would occur on privately owned lands, with relatively little development of publicly owned lands. White-tailed deer and other wildlife utilize suitable habitats despite ownership boundaries. No known distribution information relevant to land ownership is available for white-tailed deer. It is possible in areas that receive relatively high hunting pressure on publicly owned lands, that white-tailed deer may prefer suitable habitats on privately owned lands and temporarily avoid otherwise suitable habitats on publicly owned lands. Under such an assumption and if project activities occur in sufficient densities on privately owned lands, some white-tailed deer may not prefer habitats on privately owned lands and thus remain on publicly owned lands. Issues relating to white-tailed deer and other wildlife occurrence patterns on lands of different ownership (e.g., privately owned versus publicly owned) and the potential effects from project activities are speculative due to the undetermined density and local pattern of project activities, including the effects of new access roads. The effects from new access roads is difficult to quantify because road densities and lengths are dependent upon specific facility locations, which are undetermined at this time.

Noise and Dust

Elevated noise levels associated with increased human activity and facility operations may affect white-tailed deer. Elevated noise levels may deter white-tailed deer from utilizing localized areas of suitable habitat. The effects of Project-related noise levels to white-tailed deer would depend upon the occurrence pattern and intensity of produced noise. White-tailed deer responses may vary from tolerance to avoidance of local habitats. Due to the availability of alternate suitable white-tailed deer habitats throughout much of the Project Area, localized elevated noise levels are not expected to result in decreased condition or an increased mortality rate of white-tailed deer in the Project Area.

The generation and deposition of dust on suitable white-tailed deer forage may occur along existing and new access roads within the Project Area. The accumulation of dust on suitable white-tailed deer forage would likely be limited to habitats immediately adjacent to unimproved roads and represent a relatively small fraction of the total available forage within a typical white-tailed deer range. The loss of potential forage due to the accumulation of dust would not affect the survivability or condition of white-tailed deer individuals or populations.

Water Handling

The proportion of different water handling methods varies across sub-watersheds (refer to Chapter 2 for details). The number of proposed CBM wells by alternative can be used to estimate the associated disturbance to big game ranges by water handling methods. Under Alternative 1, the total number of proposed CBM wells within white-tailed deer ranges is 2,824, of which more than all occur within white-tailed deer yearlong range. No proposed wells, under this alternative

occur in winter yearlong range. Approximately 2,813 acres would be disturbed by water handling methods under this alternative (Table 4–39).

Construction of water handling facilities would likely occur in upland situations; however, the exact location and habitat type for these facilities is currently undetermined. Because sagebrush shrublands and short- and mixed-grass habitats are the most common and widely distributed habitat types within the Project Area, it is assumed these habitat types would experience the majority of disturbance associated with the construction of water handling facilities (refer to the vegetation section of this chapter). The destruction of suitable white-tailed deer habitats following the construction of various water handling facilities may have both positive and negative effects to white-tailed deer. The loss of suitable habitats due to the construction of water handling facilities would not limit the occurrence or availability of these habitats over the home range (approximately 19 acres; Fitzgerald et al., 1994). The relative amount of habitat loss would be outweighed by the availability and widespread occurrence of suitable habitat throughout the Project Area. Some methods of water handling facilities under this alternative may provide white-tailed deer and other wildlife additional drinking water resources and may increase the amount of forage available in wetland and riparian areas that expand in response to surface discharge of produced water. As fully described in Chapter 2, water quality is strictly controlled by the NPDES permitting process. Water that may be available to wildlife and livestock would meet all NPDES permitting requirements and, therefore, would not be expected to be harmful. Existing water availability conditions would influence the potential for big game concentrations to occur or increase at newly constructed water handling facilities. The distribution of existing water resources combined with the distribution of new water handling facilities would not result in concentrations of big game or other wildlife to the extent that it would be detrimental to wildlife (e.g., disease vectors) or wildlife habitats. Although water handling facilities would not be specifically intended for big game or other wildlife use, these facilities would be designed and constructed to avoid potential entrapment or drowning risks.

Mule Deer

Direct and Indirect Effects

Direct and indirect effects to mule deer and their ranges may occur as the result of activities proposed under Alternative 1. Direct effects resulting from construction of proposed CBM wells, compressors, non-CBM wells, and associated water handling methods were estimated by applying facility-specific disturbance factors to the proposed number of each facility type. These facility-specific disturbances were then summed and used to estimate the potential number of acres disturbed for each range type. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed but were not available by surface owner. Estimated disturbances to each range type are presented by surface owner and sub-watershed in Table 4–40 and Table 4–41.

Table 4–40 Direct Short-term and Long-term Effects to Mule Deer Ranges by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	17,679	6.321	0	0	52	18	8,230	2,905	73,676	26,244	99,637	35,488
Yearlong	8,107	2,901	0	0	2,218	795	4,690	0	68,613	24,848	83,628	30,206
Total	25,786	9,222	0	0	2,270	813	12,920	2,905	142,289	51,092	183,265	65,694

Table 4–41 Direct Short-term and Long-term Effects to Mule Deer Ranges by Sub-watershed — Alternative 1

	Mule Deer Ranges					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	18,025	8,447	1,101	1,090	19,126	9,537
Middle Fork Powder River	0	0	17	14	17	14
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	56,803	25,109	29,272	10,742	86,075	35,851
South Fork Powder River	0	0	6	5	6	5
Salt Creek	985	357	144	1,369	1,129	1,726
Crazy Woman Creek	11,869	4,183	4,689	1,724	16,558	5,907
Clear Creek	14,817	5,245	2,884	1,708	17,701	6,953
Middle Powder River	4,531	2,031	1,394	508	5,925	2,539
Little Powder River	3,095	1,093	13,324	5,215	16,419	6,308
Little Missouri River	0	0	0	0	0	0
Antelope Creek	770	279	20,789	7,293	21,559	7,572
Dry Fork Cheyenne River	0	0	11	9	11	9
Upper Cheyenne River	0	0	1,076	406	1,076	406
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche River	0	0	11,873	4,260	11,873	4,260
Middle North Platte Casper	0	0	0	0	0	0
Total	110,895	46,743	86,596	34,356	197,491	81,099

Habitat Disturbance

There are approximately 7,193,380 acres of mule deer range in the Project Area, including winter yearlong, yearlong, and spring/summer/fall ranges. Direct disturbance to the various types of mule deer ranges would result from construction of well pads, compressor stations, associated utility corridors, access roads and water handling features, as outlined in Chapter 2 of this document. Disturbance to mule deer ranges from Project activities would result in the localized reduction of available forage and increased fragmentation of existing contiguous habitats.

The concentration of potential disturbance would be variable but is not expected to result in the alteration of seasonal habitat use or herd movements of mule deer within the Project Area.

Approximately 81,099 acres of mule deer range would be disturbed during the life of the Project (e.g., long-term). Approximately 46,743 acres of disturbance would occur in mule deer winter yearlong range that represents approximately 58 percent of the total disturbance. Mule deer winter yearlong range occurs in most sub-watersheds within the Project Area, except the Upper Belle Fourche River and Upper Cheyenne River sub-watersheds and is typically dominated short- and mixed-grass prairie, sagebrush shrubland, and other shrubland. Approximately two percent of winter-yearlong would be disturbed during the life of the Project. Approximately 34,356 acres, or one percent, of mule deer yearlong range would be disturbed during the life of the Project. Mule deer yearlong range occurs in nearly all of the sub-watersheds throughout the Project Area and is typically dominated by short-grass prairie, sagebrush shrublands, and mixed-grass prairie. Mule deer spring/summer/fall range (127,819 acres in Project Area) is restricted to the Middle Fork Powder River sub-watershed and would not be disturbed by actions proposed under Alternative 1. The loss of suitable mule deer habitats would not likely result in adverse effects to seasonal habitat use or herd movements or condition because of the availability of suitable habitat throughout the Project Area.

These estimates of range disturbance apply to the entire life of the Project. The amount of range disturbance at any one time during project implementation would be less than these estimates, because as new areas are disturbed by development other areas would be undergoing reclamation following development that is completed.

Habitat Fragmentation

Habitat fragmentation may occur in some suitable mule deer habitats from the construction of project-related facilities (e.g., access roads). The extent of potential fragmentation is unknown because the precise location of project-related facilities is undetermined at this time. The potential effects of habitat fragmentation are dependent upon several factors including existing habitat condition and fragmentation, proximity of additional suitable habitats, degree of proposed disturbance and fragmentation, and local population size. Because these determinant factors are largely unknown at this time, it is difficult to quantify the effects of additional fragmentation. Mule deer may avoid habitat that is otherwise suitable, depending on the extent of fragmentation. The effects of potential fragmentation would not likely adversely affect the mule deer because of the widespread occurrence and availability of suitable habitats throughout the Project Area.

Vehicle Collisions

Increased human activity as the result of project implementation may have several effects on mule deer. Increased vehicle traffic is anticipated in association with the construction, production, and reclamation/abandonment phases of the Project. Quantifiable effects to mule deer as the result of increased vehicle traffic are not available; however, the potential for vehicle collisions with mule deer is

expected to be directly correlated with the volume of traffic. Project-related traffic volumes are expected to be greatest during the construction phase and gradually diminish in the production and reclamation/abandonment phases.

Human Disturbance

Mule deer would potentially be temporarily displaced from suitable habitats in areas of concentrated human activity. Displacement would likely be dependent on the activity duration and intensity (i.e., drill rig operations versus survey work). When displaced, mule deer would move to other adjacent suitable habitats. Big game sensitivity to human disturbance is difficult to quantify, nonetheless, compared to some other big game species, mule deer are less sensitive to temporary or short-term human activities, and therefore, the potential distance and duration of displacement is expected to be more than other big game species. Displacement due to concentrations of human activity are not expected to cause detrimental effects to mule deer because human disturbance would likely be limited temporarily and spatially, and suitable mule deer habitats are available.

Diversion from Public to Privately Owned Lands

Project actions are proposed for lands owned by public agencies (e.g., BLM and USFS), the State of Wyoming, and individual private owners. The majority of human activity associated with the Project would occur on privately owned lands, with relatively little development of publicly owned lands. Mule deer and other wildlife utilize suitable habitats despite ownership boundaries. No known distribution information relevant to land ownership is available for mule deer. It is possible in areas that receive relatively high hunting pressure on publicly owned lands, that mule deer may prefer suitable habitats on privately owned lands and temporarily avoid otherwise suitable habitats on publicly owned lands. Under such an assumption and if project activities occur in sufficient densities on privately owned lands, some mule deer may not prefer habitats on privately owned lands and thus remain on publicly owned lands. Issues relating to mule deer and other wildlife occurrence patterns on lands of different ownership (e.g., privately owned versus publicly owned) and the potential effects from project activities are speculative due to the undetermined density and local pattern of project activities, including the effects of new access roads. The effects from new access roads is difficult to quantify because road densities and lengths are dependent upon specific facility locations, which are undetermined at this time.

Noise and Dust

Elevated noise levels associated with increased human activity and facility operations may affect mule deer. Elevated noise levels may deter mule deer from utilizing localized areas of suitable habitat. The effects of Project-related noise levels to mule deer would depend upon the occurrence pattern and intensity of produced noise. Mule deer responses may vary from tolerance to avoidance of affected habitats. Due to the availability of alternative suitable mule deer habitats throughout much of the Project Area, localized elevated noise levels are not expected to result in decreased condition or an increased mortality rate of mule deer in the Project Area.

The generation and deposition of dust on suitable mule deer forage may occur along existing and new roads within the Project Area. The accumulation of dust on suitable mule deer forage would likely be limited to habitats immediately adjacent to unimproved roads and represent a relatively small fraction of the total available forage within a typical mule deer range. The loss of potential forage due to the accumulation of dust would not affect the survivability or condition of mule deer individuals or populations.

Water Handling

The proportion of different water handling methods varies across sub-watersheds (refer to Chapter 2 for details). The number of proposed CBM wells by alternative can be used to estimate the associated disturbance to big game ranges by water handling methods. Under Alternative 1, the total number of proposed CBM wells within mule deer ranges is 17,628, of which more than 14,804 wells (84 percent of total) would occur in mule deer winter yearlong range. A total of approximately 14,027 acres would be disturbed in mule deer winter yearlong (14,804 acres) and yearlong (2,813 acres) by water handling methods under this alternative (Table 4–42).

Table 4–42 Mule Deer Water Handling Disturbance Acres by Sub-watershed — Alternative 1

	Yearlong		Winter Yearlong		Total	
Sub-watershed	H_2O Handling No. of wells	H_2O Handling Disturbance Acres	H_2O Handling No. of wells	H_2O Handling Disturbance Acres	H_2O Handling No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0
Upper Tongue River	863	1,040	2,589	3,120	3,452	4,160
Middle Fork Powder	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0
Upper Powder River	806	528	11,496	7,530	12,302	8,058
South Fork Powder	0	0	0	0	0	0
Salt Creek	0	0	31	28	0	0
Crazy Woman Creek	156	112	0	0	156	112
Clear Creek	881	1,031	0	0	881	1,031
Middle Powder	18	15	688	564	706	579
Little Powder	72	59	0	0	72	59
Little Missouri	0	0	0	0	0	0
Antelope	9	8	0	0	9	8
Dry Fork Cheyenne	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	19	20	0	0	19	20
Middle N Platte Casper	0	0	0	0	0	0
Total	2,824	2,813	14,804	11,242	17,628	14,027

Construction of water handling facilities would likely occur in upland situations; however, the exact location and habitat type for these facilities is currently undetermined. Because sagebrush shrublands and short- and mixed-grass habitats are the most common and widely distributed habitat types within the Project Area, it

is assumed these habitat types would experience the majority of disturbance associated with the construction of water handling facilities (refer to the vegetation section of this chapter). The destruction of suitable mule deer habitats following the construction of various water handling facilities may have both positive and negative effects to mule deer. The loss of suitable habitats due to the construction of water handling facilities would not limit the occurrence or availability of these habitats over the home range of individual mule deer. The relative amount of habitat loss would be outweighed by the availability and widespread occurrence of suitable habitat throughout the Project Area. The operation of water handling facilities under this alternative may provide mule deer and other wildlife additional drinking water resources and may increase the amount of forage available in wetland and riparian areas that expand in response to surface discharge of produced water. As fully described in Chapter 2, water quality is strictly controlled by the NPDES permitting process. Water that may be available to wildlife and livestock would meet all NPDES permitting requirements and, therefore, would not be expected to be harmful. Existing water availability conditions would influence the potential for big game concentrations to occur or increase at newly constructed water handling facilities. The distribution of existing water resources combined with the distribution of new water handling facilities would not result in concentrations of big game or other wildlife to the extent that it would be detrimental to wildlife (e.g., disease vectors) or wildlife habitats. Although water handling facilities would not be specifically intended for big game or wildlife use, these facilities would be designed and constructed to avoid potential or drowning risks.

Elk

Direct and Indirect Effects

Direct and indirect effects to elk and their ranges may occur as the result of activities proposed under Alternative 1. Direct effects resulting from construction of proposed CBM wells, compressors, non-CBM wells, and associated water handling methods were estimated by applying facility-specific disturbance factors to the proposed number of each facility type. These facility-specific disturbances were then summed and used to estimate the potential number of acres disturbed for each range type. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed but were not available by surface owner.

This analysis is restricted to elk and elk ranges that occur within the Fortification Creek Area in the Upper Powder River sub-watershed. This area contains several overlapping elk ranges and is expected to experience disturbance from the construction and operation of CBM wells, non-CBM wells, compressors, and water handling facilities. Additional elk ranges exist along the southern and western boundaries of the Project Area, outside of Fortification Creek, but are expected to be disturbed only by the construction of non-CBM wells. Estimates of total disturbance in these ranges outside of Fortification Creek are less than 300 acres out of approximately 610,000 acres of range. The level of disturbance to elk and their ranges outside of Fortification Creek would not likely result in detrimental effects to seasonal habitat use, herd movements or herd condition because of the availability of remaining undisturbed habitat throughout the Project Area. Esti-

mated disturbances to each range type within Elk Fortification Creek are presented by surface owner and sub-watershed in Table 4–43, Table 4–44, Table 4–45, and Table 4–46.

Table 4–43 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	50	41	28	23	39	32	6	5	132	108	254	208
Crucial Winter Yearlong	11	9	0	0	0	0	17	14	17	14	44	36
Crucial Winter	11	9	0	0	0	0	11	9	33	27	55	45
Spring, Summer, Fall	6	5	0	0	0	0	0	0	11	9	17	14
Winter	0	0	0	0	0	0	0	0	17	14	17	14
Winter Yearlong	11	9	0	0	11	9	0	0	28	23	50	41
Total	89	73	28	23	50	41	33	27	237	194	599	357

Table 4–44 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Sub-watershed — Alternative 1

	Elk Ranges (acres)													
	Crucial Winter		Yearlong		Crucial Winter Yearlong		Spring, Summer, Fall		Winter		Winter Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	6	5	0	0	0	0	0	0	0	0	6	5	6	5
Middle Fork Powder River	0	0	44	36	11	9	0	0	0	0	55	45	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	6	5	0	0
Upper Powder River	0	0	0	0	0	0	0	0	0	0	39	32	0	0
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	6	5	0	0
Salt Creek	0	0	0	0	0	0	0	0	0	0	28	23	0	0
Crazy Woman Creek	0	0	0	0	0	0	6	5	0	0	6	5	0	0
Clear Creek	0	0	0	0	6	5	11	9	0	0	17	14	0	0
Middle Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0	6	5	55	45	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	0	0	17	14	94	77	0	0
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0	0	0	0	0	0	11	9	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	6	5	44	36	17	14	17	14	22	18	319	261	6	5

Table 4–45 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	Buffalo FO		Casper FO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	3,540	1,276	0	0	0	0	675	245	3,870	2,916	8,085	2,916
Parturition	1,416	514	0	0	0	0	342	125	1,534	1,194	3,292	1,194
Winter Yearlong	1,948	702	0	0	0	0	446	162	2,125	1,634	4,519	1,634
Crucial Winter Range	467	170	0	0	0	0	215	78	1,308	724	1,990	724

Table 4–46 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Sub-watershed — Alternative 1

	Elk Ranges (acres)							
	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0
Upper Powder River	9,531	4,364	3,875	1,776	5,324	2,438	2,338	1,072
South Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	9,531	4,364	3,875	1,776	5,324	2,438	2,338	1,072

Habitat Disturbance

There are approximately 122,931 acres of elk range in the Fortification Creek Area. Several ranges occur in Fortification Creek and overlap over the same habitats. Because of this overlapping nature, it is not appropriate to sum the totals of each range to estimate the total acres of range within this area. Although elk ranges in this area overlap, they are not precisely concentric. Crucial winter, parturition, winter yearlong and yearlong ranges occur in Fortification Creek. Direct disturbance to elk ranges would result from construction of well pads, compressor stations, associated utility corridors, access roads and water handling features,

as outlined in Chapter 2 of this document. Disturbance to elk ranges from project activities would result in the localized reduction of available forage and increased fragmentation of existing contiguous habitats which may have varying effects depending time of year.

If evaluated by percentage of potential disturbance to each range type within Fortification Creek, the greatest estimated disturbance to a single range type is 4 percent disturbance to yearlong range (4,364 acres of disturbance in 122,931 acres). Each of the other ranges would experience 3 percent disturbance during the life of the project (e.g., long-term). Sagebrush shrublands, short- and mixed-grass prairie, agriculture, and herbaceous riparian areas typically dominate these ranges. Elk yearlong range occurs in nearly all of the sub-watersheds throughout the Project Area and is typically dominated by short-grass prairie, sagebrush shrublands, and mixed-grass prairie.

These estimates of range disturbance apply to the entire life of the project. The amount of range disturbance at any one time during project implementation would be less than these estimates, due to the phased nature of development (i.e. as new areas are disturbed by development, other areas would be undergoing reclamation following development that is completed).

Habitat Fragmentation

Habitat fragmentation may occur in some suitable elk habitats from the construction of project-related facilities (e.g., access roads). The extent of potential fragmentation is unknown because the precise location of project-related facilities is undetermined at this time. The potential effects of habitat fragmentation are dependent upon several factors, including existing habitat condition and fragmentation, proximity of additional suitable habitats, degree of proposed disturbance and fragmentation, and local population size. Because these determinant factors are largely unknown at this time, it is difficult to quantify the effects of additional fragmentation. Potential fragmentation of habitats in the Fortification Creek Area may effect elk over various seasons due to the overlapping nature of ranges in this area. Elk may avoid habitat that is otherwise suitable, depending on the extent of fragmentation. The effects of potential fragmentation would likely be mitigated by implementing the measures and stipulations provided in Chapter 5 and Appendices C and D of this document.

Vehicle Collisions

Increased human activity as the result of project implementation may have several effects on elk. Increased vehicle traffic is anticipated in association with the construction, production, and reclamation/abandonment phases of the Project. Quantifiable effects to elk as the result of increased vehicle traffic are not available; however, the potential for vehicle collisions with elk is expected to be directly correlated with the volume of traffic. Project-related traffic volumes are expected to be greatest during the construction phase and gradually diminish in the production and reclamation/abandonment phases.

Human Disturbance

Elk would potentially be temporarily displaced from suitable habitats in areas of concentrated human activity. Displacement would likely be dependent on the activity duration and intensity (i.e., drill rig operations versus survey work). When displaced, elk would move to other adjacent suitable habitats. Big game sensitivity to human disturbance is difficult to quantify, nonetheless, compared to some other big game species, elk are less sensitive to temporary or short-term human activities, and therefore, the potential distance and duration of displacement is expected to be more than other big game species. Displacement due to concentrations of human activity are not expected to cause detrimental effects to elk because human disturbance would likely be limited temporarily and spatially, and suitable elk habitats are available.

Diversion from Public to Privately Owned Lands

Project actions are proposed for lands owned by public agencies (e.g., BLM and FS), the State of Wyoming, and individual private owners. The majority of human activity associated with the Project would occur on privately owned lands, with relatively little development of publicly owned lands. Elk and other wildlife utilize suitable habitats despite ownership boundaries. No known distribution information relevant to land ownership is available for elk. It is possible in areas that receive relatively high hunting pressure on publicly owned lands, that elk may prefer suitable habitats on privately owned lands and temporarily avoid otherwise suitable habitats on publicly owned lands. Under such an assumption and if project activities occur in sufficient densities on privately owned lands, some elk may not prefer habitats on privately owned lands and thus remain on publicly owned lands. Issues relating to elk and other wildlife occurrence patterns on lands of different ownership (e.g., privately owned versus publicly owned) and the potential effects from project activities are speculative due to the undetermined density and local pattern of project activities, including the effects of new access roads. The effects from new access roads is difficult to quantify because road densities and lengths are dependent upon specific facility locations, which are undetermined at this time.

Noise and Dust

Elevated noise levels associated with increased human activity and facility operations may affect elk. Elevated noise levels may deter elk from utilizing localized areas of suitable habitat. The effects of Project-related noise levels to elk would depend upon the occurrence pattern and intensity of produced noise. Elk responses may vary from tolerance to avoidance of affected habitats. Due to the availability of alternative suitable elk habitats throughout much of the Project Area, localized elevated noise levels are not expected to result in decreased condition or an increased mortality rate of elk in the Project Area.

The generation and deposition of dust on suitable elk forage may occur along existing and new roads within the Project Area. The accumulation of dust on suitable elk forage would likely be limited to habitats immediately adjacent to unimproved roads and represent a relatively small fraction of the total available forage within a typical elk range. The loss of potential forage due to the accumu-

lation of dust would not affect the survivability or condition of elk individuals or populations.

Water Handling

The proportion of different water handling methods varies across sub-watersheds (refer to Chapter 2 for details). The number of proposed CBM wells by alternative can be used to estimate the associated disturbance to big game ranges by water handling methods. Under Alternative 1, more CBM wells (2,209) are proposed in elk yearlong range in the Fortification Creek Area, than any other range type. These wells would account for approximately 1,447 acres of disturbance. Table 4–47 presents the estimated disturbance to elk ranges in Fortification Creek from water handling methods.

Table 4–47 Elk (Fortification Creek only) Water Handling Disturbance Acres by Sub-watershed — Alternative 1

	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	2,209	1,447	888	582	1,228	804	532	348
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder	0	0	0	0	0	0	0	0
Little Powder	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle N Platte Casper	0	0	0	0	0	0	0	0
Total	2,209	1,447	888	582	1,228	804	532	348

Construction of water handling facilities would likely occur in upland situations; however, the exact location and habitat type for these facilities is currently undetermined. Because sagebrush shrublands and short- and mixed-grass habitats are the most common and widely distributed habitat types within the Fortification Creek Area, it is assumed these habitat types would experience the majority of disturbance associated with the construction of water handling facilities (refer to the vegetation section of this chapter). The destruction of suitable elk habitats following the construction of various water handling facilities may have both positive and negative effects to elk. The loss of suitable habitats due to the construction of water handling facilities would not limit the occurrence or availabil-

ity of these habitats over the home range of individual elk. The relative amount of habitat loss would be outweighed by the availability and widespread occurrence of suitable habitat throughout the Project Area. The operation of water handling facilities under this alternative may provide elk and other wildlife additional drinking water resources and may increase the amount of forage available in wetland and riparian areas that expand in response to surface discharge of produced water. As fully described in Chapter 2, water quality is strictly controlled by the NPDES permitting process. Water that may be available to wildlife and livestock would meet all NPDES permitting requirements and, therefore, would not be expected to be harmful. Existing water availability conditions would influence the potential for big game concentrations to occur or increase at newly constructed water handling facilities. The distribution of existing water resources combined with the distribution of new water handling facilities would not result in concentrations of big game or other wildlife to the extent that it would be detrimental to wildlife (e.g., disease vectors) or wildlife habitats. Although water handling facilities would not be specifically intended for big game or wildlife use, these facilities would be designed and constructed to avoid potential entrapment or drowning risks.

Moose

Under Alternative 1, proposed well pads, compressors, and other facilities would not affect any of the five moose ranges that occur in the Project Area (Figure 3–14).

Raptors

Direct and Indirect Effects

Several raptor species may occur in the Project Area and these raptors have diverse habitat and prey species preferences. Collectively, habitat disturbance due to project-related activities may result in the loss of suitable raptor nesting and wintering habitats and the loss of preferred prey species habitats and possible reductions in prey base numbers. Quantification of potential losses is directly associated with expected losses by vegetation type. This information is presented in the Vegetation section of this Chapter. Ground-nesting raptors are likely to experience the most substantial direct loss of suitable nesting habitats. Cliff and tree-nesting raptors are less likely to experience loss of suitable nesting substrates because these habitats are not expected to be directly affected by the proposed actions. Wintering roosts used by bald eagles and other wintering raptors would not be expected to be directly impacted because several mitigation measures institute surface disturbance buffers and timing restrictions (refer to Chapter 5 and Appendix C).

Human Disturbance

Human disturbance may result in effects to raptors in the Project Area. Human disturbances during the life of the Project may vary by type and intensity ranging from one-time pedestrian surveys of development areas, well pad construction and well development, to regular maintenance trips to wells. Raptors have been known to become accustomed to some human activities, particularly activities that occur regularly and predictably. However, in some cases, particularly nesting

and wintering roosts, raptors may exhibit particular sensitivities to nearby human activities, regardless of the activity and its intensity. Disturbance to nesting raptors can cause nest failure, nest abandonment, and unsuccessful fledging of young. Measures to mitigate these potential effects, including timing restrictions and surface disturbance buffer zones, are presented in Chapter 5 and Appendix C of this document. The implementation of these measures is expected to reduce the effects of human disturbance to nesting and wintering raptors and preclude any effects to local breeding or wintering raptor populations.

Increased Perch Availability and Use

As part of the proposed Project, utility lines would be constructed above- and below-ground. Aboveground power lines and support structures would be used to provide power to individual well pods. From centralized pods, power would be distributed using underground lines. Support structures associated with aboveground power lines are expected to be used as perches by raptors. These perches may provide raptors with new opportunities for hunting and capturing prey. This benefit is expected to be temporary because if new perch sites actually increase hunting success, the number and density of prey species may eventually decrease due to increased hunting pressure. This would then be the limiting factor to raptor populations.

Raptor Collisions and Electrocutions

The presence of new aboveground power lines may increase the potential for raptor collisions and electrocutions. All aboveground support structures would be equipped with APLIC-approved devices intended to prevent and reduce the risk of electrocution to perching raptors. Other APLIC recommendations for line spacing and distribution may be used to minimize potential avian collisions. Power lines from individual well pods to the facilities within each pod would be constructed underground. These lines are expected to account for the majority of the new lines constructed during the life of the Project.

Increased vehicular traffic may result in increased collisions with raptors. Raptor collisions with vehicles are often associated with carrion-feeding raptors along high-speed roadways. Because project-related activities are expected to increase commercial and private traffic levels on public highways within the Project Area, the potential for raptor collision along these existing highways is expected to increase. The increase in vehicle collisions with individual raptors is not expected to contribute to the loss of raptor population viability or health. Due to the unimproved nature of the existing and proposed access roads, vehicle speeds are not expected to be similar to highway speeds and, therefore, vehicle collisions with raptors would not expected to be common. Any potential collisions with raptors along secondary or unimproved access roads would not be expected to result in detrimental changes in local raptor populations.

Prey Availability

The diverse raptor population that occurs in the Project Area relies upon a wide variety of prey species that utilize many different habitats. Quantification of potential reduction in prey populations as the result of Project activities can only be

evaluated by reviewing the potential losses by vegetation type. Prey species, particularly small- and medium-sized mammals, may experience losses due to direct mortality and/or loss of habitat. These potential losses are not expected to result in detrimental effects to local prey populations or to locally occurring raptors. In some instances, particularly with water handling methods, local habitat conditions may improve from the increased water availability and, in turn, benefit local prey species and their dependent predators, including raptors. These benefits may be considered non-permanent, because any improved water availability conditions are expected to return to pre-project levels following the life of the Project. Local prey species may experience a temporary shift in population levels, while population numbers respond to new environmental conditions. These potential population shifts are not expected to be detrimental to the survivability or fitness of these populations and would not have detrimental impacts to local raptor species populations.

Water Handling

Water handling methods would most likely affect prey habitats and, subsequently, prey population numbers, but water handling methods would not likely directly affect raptors or their habitats. Potential adverse effects of water handling facilities may include localized destruction of prey habitats and possible changes in population numbers of locally occurring prey species (e.g., small- and medium-sized mammals). Any potential effects to local prey populations would be highly localized and not expected to affect prey populations at scale relevant to predatory species, including raptors. Potential effects to raptors from water handling methods are expected to be limited to indirect effects, due to potential changes to habitats. For more information regarding potential effects to habitats refer to the vegetation section of this chapter.

Upland Game Birds

Effect types and potential impacts to sage grouse and plains sharp-tailed grouse are expected to be similar. Because these species also share similar habitats and behavior, this analysis of potential effects and impacts will address both species.

Direct and Indirect Effects

Habitat disturbance due to project-related activities may result in the direct disturbance or loss of important breeding grounds (leks) and brood rearing habitats. To avoid direct disturbance to leks, data regarding lek location and seasonal use would be reviewed before initiating ground surface disturbance. Mitigation measures listed at the end of this chapter and stipulations provided in Chapter 5 and Appendix C would be applied to avoid direct disturbance to leks. Habitat disturbance to brood-rearing habitats (riparian areas) and feeding and resting areas (sagebrush shrublands) would be expected during the life of the Project. Disturbances to riparian areas would be minimal in nature due to the intent to avoid disturbance to these areas and the implementation of several measures to limit disturbance in cases when riparian areas would be disturbed (see wetland/riparian section in this chapter). Short-term disturbance to sagebrush shrublands would occur over approximately 86,000 acres within the Project Area. This accounts for approximately four percent of the available sagebrush vegetation type within the Project Area (2,234,129 acres). The potential impacts to sage grouse would be

dependent upon the pattern of development and how the development fragments patches of suitable sagebrush shrubland at a scale relevant to sage grouse. It would be expected that sagebrush shrubland habitats of sufficient size and quality would be available for sage grouse in most scenarios of development.

Human Disturbance

Human disturbance associated with project-related activities, including noise from Project facilities, may result in adverse effects to sage grouse. Sage grouse are most sensitive to human activity and noise when on their seasonal breeding grounds (leks). Although human activities may disturb individually nesting sage grouse, possible effects to groups of grouse on their breeding grounds would be expected to have greater potential to affect local populations of this species. Mitigation measures listed at the end of this chapter and stipulations provided in Chapter 5 and Appendices C and D would be applied to avoid disturbance to sage grouse on leks. These efforts would be expected to minimize disturbance to sage grouse on their leks and, therefore, reduce the potential for detrimental effects to local sage grouse populations.

Predation by Raptors

As a possible outcome of implementing the proposed Project, raptor species may benefit from the increased availability of hunting perches from the installation of aboveground power lines. The availability of these perches may result in increased raptor hunting pressures on sage grouse, particularly when grouse are on the leks. Lek abandonment has been documented where power lines are within ½ mile and visible from the lek. Sage grouse have also been documented avoiding otherwise suitable habitats within ½ mile of power lines (San Miguel Basin Sage Grouse Working Group 1998).

Collisions

Sage grouse collisions with vehicles and aboveground power lines may increase due to project-related activities. Vehicle traffic patterns are expected to increase over current patterns and fluctuate by intensity and frequency during the life of the Project. These changes may increase the potential for collisions with sage grouse and other wildlife species.

Water Handling

Under this alternative, water-handling methods may have positive and negative effects to the sage grouse. Production waters from outflows or surface discharge water handling practices may supplement existing or create new wetland and riparian habitats. These new habitats would provide additional brood-rearing habitats for sage grouse. Water impoundments and increased water flows would also provide additional drinking water sources for sage grouse. The construction of water handling facilities would result in the loss of sagebrush shrublands that are used as nesting habitat by this species. Additional losses of sagebrush may occur from the LAD method for production water. A summary of losses by habitat type, including contributions from water handling methods are presented in the vegetation section of this chapter.

Waterfowl

Habitat Disturbance

Habitat disturbance as the result of applied water handling methods would result in a variety changes, including possible negative and positive effects to waterfowl habitats. Water from surface impoundment outflows and direct surface discharge may create new and improve existing feeding, nesting, and resting habitats, by supplementing current seasonal water regimes. These potential changes would occur in naturally existing terrain conditions and not associated with surface containment facilities. Surface containment facilities may also provide new feeding, nesting, and resting habitats to local waterfowl.

Production water from surface outflows and direct surface discharge may also negatively affect existing waterfowl habitats. Dependent upon specific site conditions, inputs to existing aquatic habitats from production water may alter favorable conditions to the detriment of plants and aquatic life. These potential effects are dependent upon existing conditions, quantity, and timing of the release of production waters, and distance between release points and existing waterfowl habitats. Although these potential effects are possible, they are not expected to detrimentally affect the survivability or condition of local regional waterfowl populations.

Exposure to Production Water

Concentrations of salts and metals, particularly barium, are expected to increase in the waters of the containment reservoirs as water evaporates over time. Such concentrations have not yet been predicted quantitatively, so precise descriptions of direct and indirect effects to waterfowl are not possible at this time. It is speculated that indirect effects (e.g., changes to waterfowl foods and nesting cover) are likely to be more important than direct effects (i.e., toxicity) to waterfowl. Salinity limits and optimum ranges for microbial communities, algae, and aquatic invertebrates are known for many species and can be found in the scientific literature (Adamus 1996). It is presumed that the containment reservoirs will be colonized by species of these taxa that are tolerant of the excessively saline water quality conditions relative to surrounding water bodies.

The species richness of microbial communities and aquatic invertebrates, as well as algal productivity and biomass, can be expected to be less in the containment reservoirs than less-saline local water bodies based on a number of scientific studies (Adamus 1996). As the salinity increases over time and as water evaporates from the containment reservoirs, these bioindicators will evidence a negative correlation. Similarly, the species richness and abundance of waterfowl is expected to be low and less than surrounding unaffected water bodies.

The direct effects to waterfowl from increasing concentrations of metals in the containment reservoirs cannot be well surmised without quantitative predictions of the concentrations. Selenium levels in the water column of greater than 0.050 mg/L are considered to pose a potential risk to many waterbird species, due to the element's known toxicological effects and high bioaccumulation potential in food chains. The saline quality of the water is expected to cause precipitation of dissolved metals in the water column, such that sediments will receive increasing concentrations of organic and inorganic forms of the metals contained in the CBM-produced waters over time. It is possible that eventually the sediments may reach a toxic level for diving ducks that ingest sediments while feeding on benthic organisms. Changes in algal and microbial species richness that could cause indirect effects on waterfowl may or may not occur in response to increasing metals concentrations (Adamus 1996).

Alternative 2A

Alternative 2A is similar to Alternative 1 in the type and magnitude of disturbance associated with the project. However, Alternative 2A does differ in the proportions assigned to the various water handling methods. Under this alternative, as compared to Alternative 1, there would be an increased emphasis on the use of infiltration, containment reservoirs, and LAD; and a decreased emphasis on the use of surface discharge. These differences in water handling would result in variations of habitat disturbance and would not be expected to have unique or different effect types from those presented under Alternative 1.

Terrestrial Species

Big Game

Pronghorn

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–48 and Table 4–49 present estimates of disturbance to range by surface owner and sub-watershed. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–50). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–48 Direct Short-term and Long-term Effects to Pronghorn Ranges by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Severe Winter	0	0	0	0	39	32	0	0	17	14	14	46
Crucial Winter												
Yearlong	0	0	0	0	0	0	0	0	0	0	0	0
Winter	1,532	582	0	0	0	0	621	261	4,860	2,205	13,919	3,048
Winter Yearlong	4,359	1,620	17	14	1,135	491	2,693	1,122	57,572	22,609	143,025	25,856
Yearlong	13,330	5,099	39	32	9,199	3,734	12,843	4,797	114,137	43,270	325,388	56,932
Spring, Summer, Fall	102	41	17	14	0	0	11	9	969	387	2,309	451
Total	19,323	7,342	73	60	10,373	4,257	16,168	6,189	177,555	68,485	484,655	86,333

Table 4–49 Direct Short-term and Long-term Effects to Pronghorn Ranges by Sub-watershed – Alternative 2A

	Disturbance (acres)													
	Severe Winter	Crucial Winter	Winter		Winter Yearlong		Yearlong		Spring, Summer, Fall		Total			
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	1,457	707	16,788	8,332	0	0	18,245	9,039
Middle Fork Powder	0	0	0	0	0	0	44	36	6	5	28	23	78	64
North Fork Powder	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Upper Powder	0	0	0	0	7,380	3,843	33,562	17,256	44,757	22,842	6	5	85,705	43,946
South Fork Powder	0	0	0	0	0	0	0	0	17	14	0	0	17	14
Salt Creek	0	0	0	0	0	0	423	170	220	114	28	23	671	307
Crazy Woman Creek	0	0	0	0	0	0	6	5	20,988	10,325	0	0	20,994	10,330
Clear Creek	0	0	0	0	0	0	3,339	1,743	17,255	9,005	0	0	20,594	10,748
Middle Powder River	0	0	0	0	321	177	0	0	5,038	2,569	1,282	646	6,640	3,391
Little Powder River	0	0	0	0	1,173	890	11,222	5,721	16,293	8,594	0	0	28,687	15,204
Little Missouri	0	0	0	0	0	0	17	14	435	356	0	0	452	370
Antelope Creek	28	23	0	0	0	0	2,165	817	43,218	16,393	0	0	45,411	17,233
Dry Fork Cheyenne	28	23	0	0	0	0	50	41	193	158	0	0	271	222
Upper Cheyenne	0	0	0	0	0	0	1,613	755	2,178	1,061	0	0	3,792	1,817
Lightning Creek	0	0	0	0	0	0	22	18	248	203	0	0	270	221
Upper Belle Fourche	0	0	0	0	0	0	26,339	13,085	10,159	5,192	0	0	36,498	18,277
Middle North Platte Casper	0	0	0	0	0	0	148	122	61	50	0	0	209	172
Total	56	46	0	0	7,956	3,992	75,887	35,970	167,755	75,113	1,249	602	252,903	115,723

Table 4–50 Pronghorn Water Handling Disturbances by Sub-watershed — Alternative 2A

	Disturbance (acres)									
	Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	186	285	2,280	3,488	2,466	3,773
Middle Fork Powder	0	0	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	1,362	1,777	5,861	7,649	7,741	10,102	14,964	19,528
South Fork Powder	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	12	20	6	10	18	30
Crazy Woman Creek	0	0	0	0	0	0	2,922	4,471	2,922	4,471
Clear Creek	0	0	0	0	556	851	2,870	4,391	3,426	5,242
Middle Powder	182	244	46	62	0	0	655	878	883	1,183
Little Powder	0	0	18	24	846	1,134	1,128	1,512	1,992	2,669
Little Missouri	0	0	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	77	85	1,567	1,739	1,644	1,825
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	242	269	291	323	533	592
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	4,225	4394	1,651	1,717	5,876	6,111
Middle N Platte Casper	0	0	0	0	0	0	0	0	0	0
Total	182	244	1,426	1,863	12,005	14,685	21,111	28,631	34,724	45,423

White-tailed Deer

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–51 and Table 4–52 present estimates or disturbance for range by surface owner and sub-watershed, respectively. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–53). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–51 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	609	246	0	0	116	59	1,837	669	13,516	5,340	16,078	6,314
Winter Yearlong	39	32	0	0	0	0	0	0	0	32	78	64
Total	648	278	0	0	116	59	1,837	669	13,516	5,372	16,156	6,378

Table 4–52 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Sub-watershed — Alternative 2A

	Disturbance (acres)					
	Winter Range		Winter Yearlong Range		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	0	0	6,620	3,264	6,620	3,264
Middle Fork Powder	0	0	17	14	17	14
North Fork Powder	0	0	0	0	0	0
Upper Powder	0	0	4,613	2,345	4,613	2,345
South Fork Powder	0	0	6	5	6	5
Salt Creek	0	0	0	0	0	0
Crazy Woman Creek	0	0	1,140	554	1,140	554
Clear Creek	0	0	5,350	2,750	5,350	2,750
Middle Powder River	39	32	126	65	165	97
Little Powder River	0	0	1,871	1,195	1,871	1,195
Little Missouri	0	0	0	0	0	0
Antelope Creek	0	0	252	100	252	100
Dry Fork Cheyenne	0	0	11	9	11	9
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	0	0	180	115	180	115
Middle North Platte Casper	0	0	0	0	0	0
Total	39	32	20,201	10,428	20,240	10,460

Table 4–53 White-tailed Deer Water Handling Disturbances by Sub-watershed — Alternative 2A

	Disturbance (acres)			
	Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0
Upper Tongue River	863	1,320	863	1,320
Middle Fork Powder	0	0	0	0
North Fork Powder	0	0	0	0
Upper Powder River	806	1,052	806	1,052
South Fork Powder	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	156	239	156	239
Clear Creek	881	1,348	881	1,348
Middle Powder	18	24	18	24
Little Powder	72	96	72	96
Little Missouri	0	0	0	0
Antelope	9	10	9	10
Dry Fork Cheyenne	0	0	0	0
Upper Cheyenne	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche	19	20	19	20
Middle N Platte Casper	0	0	0	0
Total	2,824	4,109	2,824	4,109

Mule Deer

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–54 and Table 4–55 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–56). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–54 Direct Short-term and Long-term Effects to Mule Deer Ranges by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	17,679	6,321	0	0	52	18	8,230	2,905	73,676	26,244	99,637	35,488
Yearlong	8,107	2,901	0	0	2,218	795	4,690	0	68,613	24,848	83,628	30,206
Total	25,786	9,222	0	0	2,270	813	12,920	2,905	142,289	51,092	183,265	65,694

Table 4–55 Direct Short-term and Long-term Effects to Mule Deer Ranges by Sub-watershed — Alternative 2A

	Mule Deer Ranges					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	14,910	5,329	1,562	1,518	16,472	6,847
Middle Fork Powder	0	0	17	14	17	14
North Fork Powder	0	0	0	0	0	0
Upper Powder	49,274	17,579	29,796	11,268	79,069	28,847
South Fork Powder	0	0	6	5	6	5
Salt Creek	957	329	144	50	1,101	379
Crazy Woman Creek	11,869	4,183	4,815	1,850	16,685	6,034
Clear Creek	14,817	5,245	3,201	2,025	18,018	7,270
Middle Powder River	3,972	1,469	1,404	518	5,376	1,986
Little Powder River	3,095	1,096	13,362	5,253	16,457	6,349
Little Missouri	0	0	0	0	0	0
Antelope Creek	770	279	20,780	7,286	21,550	7,565
Dry Fork Cheyenne	0	0	11	9	11	9
Upper Cheyenne	0	0	1,076	406	1,076	406
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	0	0	11,956	4,327	11,956	4,327
Middle North Platte Casper	0	0	0	0	0	0
Total	99,663	35,508	88,145	34,543	187,808	70,051

Table 4–56 Mule Deer Water Handling Disturbances by Sub-watershed — Alternative 2A

	Yearlong		Winter Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0
Upper Tongue River	863	1,320	2,589	3,961	3,452	5,282
Middle Fork Powder	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0
Upper Powder River	806	1,052	11,496	15,002	12,302	16,054
South Fork Powder	0	0	0	0	0	0
Salt Creek	0	0	31	51	31	51
Crazy Woman Creek	156	239	0	0	156	239
Clear Creek	881	1,348	0	0	881	1,348
Middle Powder	18	24	688	922	706	946
Little Powder	72	96	0	0	72	96
Little Missouri	0	0	0	0	0	0
Antelope	9	10	0	0	9	10
Dry Fork Cheyenne	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	19	20	0	0	19	20
Middle N Platte Casper	0	0	0	0	0	0
Total	2,824	4,109	14,804	19,936	17,628	24,046

Elk

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–57, Table 4–58, Table 4–59, and Table 4–60 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–61). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–57 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	17,679	6,321	0	0	52	18	8,230	2,905	73,676	26,244	99,637	35,488
Yearlong	8,107	2,901	0	0	2,218	795	4,690	0	68,613	24,848	83,628	30,206
Total	25,786	9,222	0	0	2,270	813	12,920	2,905	142,289	51,092	183,265	65,694

Table 4–58 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Sub-watershed — Alternative 2A

	Disturbance (acres)					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	14,910	5,329	1,562	1,518	16,472	6,847
Middle Fork Powder	0	0	17	14	17	14
North Fork Powder	0	0	0	0	0	0
Upper Powder	49,274	17,579	29,796	11,268	79,069	28,847
South Fork Powder	0	0	6	5	6	5
Salt Creek	957	329	144	50	1,101	379
Crazy Woman Creek	11,869	4,183	4,815	1,850	16,685	6,034
Clear Creek	14,817	5,245	3,201	2,025	18,018	7,270
Middle Powder River	3,972	1,469	1,404	518	5,376	1,986
Little Powder River	3,095	1,096	13,362	5,253	16,457	6,349
Little Missouri	0	0	0	0	0	0
Antelope Creek	770	279	20,780	7,286	21,550	7,565
Dry Fork Cheyenne	0	0	11	9	11	9
Upper Cheyenne	0	0	1,076	406	1,076	406
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	0	0	11,956	4,327	11,956	4,327
Middle North Platte Casper	0	0	0	0	0	0
Total	99,663	35,508	88,145	34,543	187,808	70,051

Table 4–59 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	3,540	1,276	0	0	0	0	675	245	3,870	2,916	8,085	2,916
Parturition	1,416	514	0	0	0	0	342	125	1,534	1,194	3,292	1,194
Winter Yearlong	1,948	702	0	0	0	0	446	162	2,125	1,634	4,519	1,634
Crucial Winter Range	467	170	0	0	0	0	215	78	1,308	724	1,990	724

Table 4–60 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Sub-watershed — Alternative 2A

	Elk Ranges							
	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder	10,965	5,798	4,452	2,353	6,123	3,237	2,684	1,418
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	10,965	5,798	4,452	2,353	6,123	3,237	2,684	1,418

Table 4–61 Elk (Fortification Creek only) Water Handling Disturbances by Sub-watershed – Alternative 2A

	Disturbance (acres)							
	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	22,080	2,881	888	1,159	1,228	1,603	532	694
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder	0	0	0	0	0	0	0	0
Little Powder	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle N Platte Casper	0	0	0	0	0	0	0	0
Total	22,080	2,881	888	1,159	1,228	1,603	532	694

Moose

Under Alternative 2A, proposed well pads, compressors, and other facilities would not affect any of the five moose ranges that occur in the Project Area.

Raptors

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water Handling

Water-handling methods would not likely affect raptors directly, but may affect habitats that support prey species. Potential adverse effects of water-handling facilities may include localized destruction of prey habitats and possible changes in population numbers of locally occurring prey species (e.g., small- and medium-sized mammals). Any potential effects to local prey populations would be highly localized and not expected to affect prey populations at scales relevant to predatory species, including raptors. For more information regarding potential effects to habitats, refer to the vegetation section of this chapter.

Upland Game Birds

Sage Grouse and Plains Sharp-Tailed Grouse

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water Handling

Water-handling methods would not likely affect grouse species directly, but would affect habitats that support these species. Potential adverse effects of water-handling facilities may include localized destruction of nesting, feeding, and brood rearing habitats. Estimates of disturbances to vegetation types are presented in the vegetation section of this chapter.

Waterfowl

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water-handling methods between Alternatives 2A and 1 differ most substantially in the number of acres disturbed from construction of infiltration impoundments. Alternative 2A would potentially disturb 32,253 acres, more than twice the acreage proposed for infiltration impoundments in Alternative 1. This shift in emphasis to infiltration impoundments may create new feeding, resting, and nesting habitats. These areas are not expected to be important to local waterfowl because of the availability of existing habitats.

Alternative 2B

Alternative 2B is similar to Alternative 1 in the type and magnitude of disturbance associated with the Project. However, Alternative 2B does differ in the proportions assigned to the various water handling methods. Under this alternative, as compared to Alternative 1, there would be an increased emphasis on the use of infiltration, containment reservoirs, and LAD; and a decreased emphasis on the use of surface discharge. These differences in water handling would result in variations of habitat disturbance and would not be expected to have unique or different effect types from those presented under Alternative 1. For a complete assessment of potential effect types, refer to Alternative 1 of this chapter.

Terrestrial Species

Big Game

Pronghorn

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–62 and Table 4–63 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–64). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–62 Direct Short-term and Long-term Effects to Pronghorn Ranges by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Severe Winter	0	0	0	0	39	32	0	0	17	14	14	46
Crucial Winter Yearlong	0	0	0	0	0	0	0	0	0	0	0	0
Winter	1,532	582	0	0	0	0	621	261	4,860	2,205	13,919	3,048
Winter Yearlong	4,359	1,620	17	14	1,135	491	2,693	1,122	57,572	22,609	143,025	25,856
Yearlong	13,330	5,099	39	32	9,199	3,734	12,843	4,797	114,137	43,270	325,388	56,932
Spring, Summer, Fall	102	41	17	14	0	0	11	9	969	387	2,309	451
Total	19,323	7,342	73	60	10,373	4,257	16,168	6,189	177,555	68,485	484,655	86,333

Table 4–63 Direct Short-term and Long-term Effects to Pronghorn Ranges by Sub-watershed — Alternative 2B

	Pronghorn Ranges													
	Severe Winter		Crucial Winter		Winter		Winter Yearlong		Yearlong		Spring, Summer, Fall		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	1,396	646	16,047	7,591	0	0	17,444	8,238
Middle Fork Powder	0	0	0	0	0	0	44	36	6	5	28	23	78	64
North Fork Powder	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Upper Powder	0	0	0	0	7,115	3,578	32,419	16,113	43,248	21,333	6	5	82,787	41,028
South Fork Powder	0	0	0	0	0	0	0	0	17	14	0	0	17	14
Salt Creek	0	0	0	0	0	0	423	170	220	114	28	23	671	307
Crazy Woman Creek	0	0	0	0	0	0	6	5	20,126	9,463	0	0	20,132	9,468
Clear Creek	0	0	0	0	0	0	3,175	1,579	16,408	8,158	0	0	19,583	9,737
Middle Powder River	0	0	0	0	309	165	0	0	4,867	2,398	1,235	599	6,411	3,162
Little Powder River	0	0	0	0	1,168	885	10,972	5,471	15,960	8,261	0	0	28,100	14,617
Little Missouri	0	0	0	0	0	0	17	14	435	356	0	0	452	370
Antelope Creek	28	23	0	0	0	0	2,170	822	43,320	16,495	0	0	45,518	17,340
Dry Fork Cheyenne	28	23	0	0	0	0	50	41	193	158	0	0	271	222
Upper Cheyenne	0	0	0	0	0	0	1,629	771	2,197	1,080	0	0	3,826	1,851
Lightning Creek	0	0	0	0	0	0	22	18	248	203	0	0	270	221
Upper Belle Fourche	0	0	0	0	0	0	26,064	12,810	10,052	5,085	0	0	36,116	17,895
Middle North Platte Casper	0	0	0	0	0	0	148	122	61	50	0	0	209	172
Total	56	46	0	0	8,591	4,627	78,535	38,618	173,411	80,769	1,297	650	261,890	124,710

Table 4–64 Pronghorn Water Handling Disturbances by Sub-watershed – Alternative 2B

	Disturbance (acres)									
	Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	186	224	2,280	2,747	2,466	2,972
Middle Fork Powder	0	0	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	1,362	1,512	5,861	6,506	7,741	8,593	14,964	16,610
South Fork Powder	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	12	20	6	10	18	30
Crazy Woman Creek	0	0	0	0	0	0	2,922	3,609	2,922	3,609
Clear Creek	0	0	0	0	556	687	2,870	3,544	3,426	4,231
Middle Powder	182	197	46	50	0	0	655	707	883	954
Little Powder	0	0	18	19	846	884	1,128	1,179	1,992	2,082
Little Missouri	0	0	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	77	75	1,567	1,536	1,644	1,611
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	242	237	291	285	533	522
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	4,225	4,119	1,651	1,610	5,876	5,729
Middle N Platte Casper	0	0	0	0	0	0	0	0	0	0
Total	182	197	1,426	1,580	12,005	12,752	21,111	23,820	34,724	38,349

White-tailed Deer

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–65 and Table 4–66 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–67). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–65 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	609	246	0	0	116	59	1,837	669	13,516	5,340	16,078	6,314
Winter Yearlong	39	32	0	0	0	0	0	0	0	32	78	64
Total	648	278	0	0	116	59	1,837	669	13,516	5,372	16,156	6,378

Table 4–66 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Sub-watershed — Alternative 2B

	Disturbance (acres)					
	Yearlong		Spring, Summer, Fall		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0
Upper Tongue River	16,047	7,591	0	0	17,444	8,238
Middle Fork Powder	6	5	28	23	78	64
North Fork Powder	6	5	0	0	6	5
Upper Powder	43,248	21,333	6	5	82,787	41,028
South Fork Powder	17	14	0	0	17	14
Salt Creek	220	114	28	23	671	307
Crazy Woman Creek	20,126	9,463	0	0	20,132	9,468
Clear Creek	16,408	8,158	0	0	19,583	9,737
Middle Powder River	4,867	2,398	1,235	599	6,411	3,162
Little Powder River	15,960	8,261	0	0	28,100	14,617
Little Missouri	435	356	0	0	452	370
Antelope Creek	43,320	16,495	0	0	45,518	17,340
Dry Fork Cheyenne	193	158	0	0	271	222
Upper Cheyenne	2,197	1,080	0	0	3,826	1,851
Lightning Creek	248	203	0	0	270	221
Upper Belle Fourche	10,052	5,085	0	0	36,116	17,895
Middle North Platte Casper	61	50	0	0	209	172
Total	173,411	80,769	1,297	650	261,890	124,710

Table 4–67 White-tailed Deer Water Handling Disturbances by Sub-watershed — Alternative 2B

	Yearlong		Total	
	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0
Upper Tongue River	863	1,040	863	1,040
Middle Fork Powder	0	0	0	0
North Fork Powder	0	0	0	0
Upper Powder River	806	895	806	895
South Fork Powder	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	156	193	156	193
Clear Creek	881	1,088	881	1,088
Middle Powder	18	19	18	19
Little Powder	72	75	72	75
Little Missouri	0	0	0	0
Antelope	9	9	9	9
Dry Fork Cheyenne	0	0	0	0
Upper Cheyenne	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche	19	19	19	19
Middle N Platte Casper	0	0	0	0
Total	2,824	3,337	2,824	3,337

Mule Deer

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–68 and Table 4–69 present estimates of disturbance for ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–70). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–68 Direct Short-term and Long-term Effects to Mule Deer Ranges by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	17,679	6,321	0	0	52	18	8,230	2,905	73,676	26,244	99,637	35,488
Yearlong	8,107	2,901	0	0	2,218	795	4,690	0	68,613	24,848	83,628	30,206
Total	25,786	9,222	0	0	2,270	813	12,920	2,905	142,289	51,092	183,265	65,694

Table 4–69 Disturbance to Mule Deer Ranges by Sub-watershed — Alternative 2B

	Disturbance (acres)					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	18,029	8,448	1,282	1,238	19,311	9,686
Middle Fork Powder	0	0	17	14	17	14
North Fork Powder	0	0	0	0	0	0
Upper Powder	62,034	30,340	29,638	11,111	91,673	41,451
South Fork Powder	0	0	6	5	6	5
Salt Creek	1,008	380	144	50	1,152	430
Crazy Woman Creek	11,869	4,183	4,769	1,804	16,639	5,988
Clear Creek	14,817	5,245	2,941	1,765	17,758	7,010
Middle Powder River	4,715	2,212	1,399	513	6,114	2,725
Little Powder River	3,095	1,096	13,341	5,231	16,435	6,328
Little Missouri	0	0	0	0	0	0
Antelope Creek	770	279	20,779	7,285	21,549	7,563
Dry Fork Cheyenne	0	0	11	9	11	9
Upper Cheyenne	0	0	1,076	406	1,076	406
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	0	0	11,954	4,326	11,954	4,326
Middle North Platte Casper	0	0	0	0	0	0
Total	116,337	52,182	87,373	33,771	203,711	85,953

Table 4–70 Mule Deer Water Handling Disturbances by Sub-watershed – Alternative 2B

	Disturbance (acres)					
	Yearlong		Winter Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0
Upper Tongue River	863	1,040	2,589	3,120	3,452	4,160
Middle Fork Powder	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0
Upper Powder River	806	895	11,496	12,761	12,302	13,655
South Fork Powder	0	0	0	0	0	0
Salt Creek	0	0	31	51	31	51
Crazy Woman Creek	156	193	0	0	156	193
Clear Creek	881	1,088	0	0	881	1,088
Middle Powder	18	19	688	743	706	762
Little Powder	72	75	0	0	72	75
Little Missouri	0	0	0	0	0	0
Antelope	9	9	0	0	9	9
Dry Fork Cheyenne	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	19	19	0	0	19	19
Middle N Platte Casper	0	0	0	0	0	0
Total	2,824	3,337	14,804	16,674	17,628	20,012

Elk

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–71, Table 4–72, Table 4–73, and Table 4–74 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–75). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–71 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	50	41	28	23	39	32	6	5	132	108	254	208
Crucial Winter Yearlong	11	9	0	0	0	0	17	14	17	14	44	36
Crucial Winter	11	9	0	0	0	0	11	9	33	27	55	45
Spring, Summer, Fall	6	5	0	0	0	0	0	0	11	9	17	14
Winter	0	0	0	0	0	0	0	0	17	14	17	14
Winter Yearlong	11	9	0	0	11	9	0	0	28	23	50	41
Total	89	73	28	23	50	41	33	27	237	194	599	357

Table 4–72 Disturbance to Elk Ranges (excluding Fortification Creek) by Sub-watershed — Alternative 2B

	Disturbance (acres)													
	Crucial Winter		Crucial Winter Yearlong		Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	6	5	0	0	0	0	0	0	0	0	0	0	6	5
Middle Fork Powder	0	0	44	36	11	9	0	0	0	0	0	0	55	45
North Fork Powder	0	0	0	0	0	0	0	0	0	0	6	5	6	5
Upper Powder	0	0	0	0	0	0	0	0	0	0	39	32	39	32
South Fork Powder	0	0	0	0	0	0	0	0	0	0	6	5	6	5
Salt Creek	0	0	0	0	0	0	0	0	0	0	28	23	28	23
Crazy Woman Creek	0	0	0	0	0	0	6	5	0	0	0	0	6	5
Clear Creek	0	0	0	0	6	5	11	9	0	0	0	0	17	14
Middle Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0	6	5	50	41	55	45
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0	17	14	77	63	94	77
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0	0	0	11	9	11	9
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	6	5	44	36	17	14	17	14	22	18	215	176	319	261

Table 4–73 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	Buffalo FO		Casper FO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	3,540	1,276	0	0	0	0	675	245	3,870	1,395	8,085	2,916
Parturition	1,416	514	0	0	0	0	342	125	1,534	555	3,292	1,194
Winter Yearlong	1,948	702	0	0	0	0	446	162	2,125	770	4,519	1,634
Crucial Winter Range	467	170	0	0	0	0	215	78	1,308	476	1,990	724

Table 4–74 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Sub-watershed — Alternative 2B

	Disturbance (acres)							
	Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder	10,535	5,368	4,279	2,180	5,883	2,997	2,581	1,315
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	10,535	5,368	4,279	2,180	5,883	2,997	2,581	1,315

Table 4–75 Elk (Fortification Creek only) Water Handling Disturbances by Sub-watershed — Alternative 2B

	Disturbance (acres)							
	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	2,208	2,451	888	986	1,228	1,363	532	591
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder	0	0	0	0	0	0	0	0
Little Powder	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle N Platte - Casper	0	0	0	0	0	0	0	0
Total	2,208	2,451	888	986	1,228	1,363	532	591

Moose

Under Alternative 2B, proposed well pads, compressors, and other facilities would not impact any of the five moose ranges that occur in the Project Area.

Raptors

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water Handling

Water handling methods would not likely affect raptors directly, but may affect habitats that support prey species. Potential adverse effects of water handling facilities may include localized destruction of prey habitats and possible changes in population numbers of locally occurring prey species (e.g., small- and medium-sized mammals). Any potential effects to local prey populations would be highly localized and not expected to affect prey populations at scales relevant to

predatory species, including raptors. For more information regarding potential effects to habitats, refer to the vegetation section of this chapter.

Upland Game Birds

Sage Grouse and Plains Sharp-tailed Grouse

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water Handling

Water handling methods would not likely affect grouse species directly, but would affect habitats that support these species. Potential adverse effects of water handling facilities may include localized destruction of nesting, feeding, and brood-rearing habitats. Estimates of disturbances to vegetation types are presented in the vegetation section of this chapter.

Waterfowl

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water handling methods between Alternative 1 and 2B differ most substantially in the number of acres disturbed from construction of infiltration impoundments. Alternative 2B would potentially disturb 23,446 acres, nearly twice the acreage proposed for infiltration impoundments in Alternative 1. This shift in emphasis to infiltration impoundments may create new feeding, resting, and nesting habitats. These areas are not expected to be important to local waterfowl because of the availability of existing habitats, but they may be utilized.

Alternative 3

Alternative 3 differs from the other alternatives in that development is restricted to non-federal leases. Because Alternative 3 is restricted to non-federal minerals, there are fewer wells and related facilities and subsequently less disturbance. Effects associated with this alternative would be similar in type to those presented in Alternative 1, 2A, and 2B but would be reduced in total disturbance acreage.

For a complete assessment of potential effect types, refer to description of Alternative 1 section in this chapter.

Terrestrial Species

Big Game

Pronghorn

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. Table 4–76 and Table 4–77 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–78).

Table 4–76 Direct Short-term and Long-term Effects to Pronghorn Ranges by Surface Owner — Alternative 3

	Surface Owner (acres)											
	BLM											
	Buffalo FO		Casper FO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Severe Winter	0	0	0	0	0	0	0	0	17	14	17	14
Crucial Winter Yearlong	0	0	0	0	0	0	0	0	0	0	0	0
Winter	0	0	0	0	0	0	621	260	1,970	1,164	2,591	1,424
Winter Yearlong	0	0	0	0	330	117	2,473	1,045	28,200	12,227	31,003	13,389
Yearlong	28	10	0	0	1,632	572	12,308	4,608	53,730	21,848	67,698	27,038
Spring, Summer, Fall	0	0	0	0	0	0	11	9	323	157	334	166
Total	28	10	0	0	1,962	689	15,413	5,922	84,240	35,410	101,643	42,031

Table 4–77 Direct Short-term and Long-term Effects to Pronghorn Ranges by Sub-watershed — Alternative 3

	Disturbance (acres)													
	Severe Winter		Crucial Winter Yearlong		Winter		Winter Yearlong		Yearlong		Spring, Summer, Fall		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	126	152	1937	2334	2063	2486	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	329	215	1512	990	2042	1338	3883	2543	0	0	329	215
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	7	6	5	5	12	11	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	936	674	936	674	0	0	0	0
Clear Creek	0	0	0	0	332	388	1884	2204	2216	2593	0	0	0	0
Middle Powder River	20	16	8	7	0	0	165	135	193	158	20	16	8	7
Little Powder River	0	0	12	10	379	311	566	464	957	785	0	0	12	10
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	39	36	564	516	603	552	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	121	111	139	127	260	238	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	2240	2330	1115	1160	3355	3489	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	20	16	349	232	4756	4324	9353	8957	14478	13529	20	16	349	232

Table 4–78 Pronghorn Water Handling Disturbances by Sub-watershed — Alternative 3

	Disturbance (acres)									
	Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	126	152	1,937	2,334	2,063	2,486
Middle Fork Powder	0	0	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	329	215	1,512	990	2,042	1,338	3,883	2,543
South Fork Powder	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	7	6	5	5	12	11
Crazy Woman Creek	0	0	0	0	0	0	936	674	936	674
Clear Creek	0	0	0	0	332	388	1,884	2,204	2,216	2,593
Middle Powder	20	16	8	7	0	0	165	135	193	158
Little Powder	0	0	12	10	379	311	566	464	957	785
Little Missouri	0	0	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	39	36	564	516	603	552
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	121	111	139	127	260	238
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	2,240	2,330	1,115	1,160	3,355	3,489
Middle N Platte Casper	0	0	0	0	0	0	0	0	0	0
Total	20	16	349	232	4,756	4,324	9,353	8,957	14,478	13,529

White-tailed Deer

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. Table 4–79 and Table 4–80 present ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–81).

Table 4–79 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Surface Owner — Alternative 3

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Year Long	66	54	0	0	354	143	4,161	1,486	25,586	9,568	30,166	11,251
Winter Year Long	39	32	0	0	0	0	0	2,662	26,835	9,564	34,343	12,258
Total	105	86	0	0	354	143	4,161	4,148	52,421	19,132	64,509	23,509

Table 4–80 Direct Short-term and Long-term Effects To White-tailed Deer Ranges by Sub-watershed — Alternative 3

	Disturbance (acres)					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	0	0	6,017	2,829	6,017	2,829
Middle Fork Powder River	0	0	17	14	17	14
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	0	0	2,568	1143	2,568	11,435
South Fork Powder River	0	0	6	5	6	05
Salt Creek	0	0	0	0	0	0
Crazy Woman Creek	0	0	723	298	723	298
Clear Creek	0	0	4,545	2,213	4,545	2,213
Middle Powder River	22	18	43	20	65	38
Little Powder River	0	0	1,046	604	1,046	604
Little Missouri River	0	0	0	0	0	0
Antelope Creek	0	0	106	40	106	40
Dry Fork Cheyenne River	0	0	6	5	6	5
Upper Cheyenne River	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche River	0	0	132	80	132	80
Middle North Platte Casper	0	0	0	0	0	0
Total	22	18	15,224	7,262	15,246	7,280

Table 4–81 White-tailed Deer Water Handling Disturbances by Sub-watershed — Alternative 3

	Disturbance (acres)			
	Year Long		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn River	0	0	0	0
Upper Tongue River	813	980	813	980
Middle Fork Powder	0	0	0	0
North Fork Powder	0	0	0	0
Upper Powder	489	320	489	320
South Fork Powder	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	104	75	104	75
Clear Creek	810	948	810	948
Middle Powder River	8	7	8	7
Little Powder River	49	40	49	40
Little Missouri	0	0	0	0
Antelope Creek	4	4	4	4
Dry Fork Cheyenne	0	4	0	4
Upper Cheyenne	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche	16	17	16	17
Middle North Platte Casper	0	0	0	0
Total	2,293	2,390	2,293	2,390

Mule Deer

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. Table 4–82 and Table 4–83 present estimates of disturbance to ranges by surface owner and sub-watershed. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–84).

Table 4–82 Direct Short-term and Long-term Effects to Mule Deer Ranges by Surface Owner — Alternative 3

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	0	0	0	0	0	0	8,051	2,842	32,241	9,564	40,292	12,406
Yearlong	66	54	0	0	354	143	4,557	0	26,590	115,173	31,567	116,987
Total	66	54	0	0	354	143	12,608	2,842	58,831	124,737	71,859	129,393

Table 4–83 Direct Short-term and Long-term Effects to Mule Deer Ranges by Sub-watershed — Alternative 3

	Disturbance (acres)					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	4,617	3,641	5,222	2,524	9,839	6,166
Middle Fork Powder River	0	0	17	14	17	14
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	9,716	8,308	3,924	1,624	13,640	9,932
South Fork Powder River	0	0	6	5	6	5
Salt Creek	115	55	0	0	115	55
Crazy Woman Creek	660	225	870	344	1,530	570
Clear Creek	1,239	421	4,182	2,110	5,422	2,531
Middle Powder River	719	626	43	20	762	646
Little Powder River	185	76	1,046	604	1,231	680
Little Missouri River	0	0	0	0	0	0
Antelope Creek	0	0	289	104	289	104
Dry Fork Cheyenne River	0	0	6	5	6	5
Upper Cheyenne River	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche River	0	0	1,004	425	1,004	425
Middle North Platte Casper	0	0	0	0	0	0
Total	17,252	13,352	16,625	7,790	33,877	21,142

Table 4–84 Mule Deer Water Handling Disturbances by Sub-watershed — Alternative 3

	Disturbance (acres)					
	Yearlong		Winter Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn River	0	0	0	0	0	0
Upper Tongue River	813	980	2,589	3,120	3,402	4,099
Middle Fork Powder	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0
Upper Powder	489	320	11,496	7,530	11,985	7,850
South Fork Powder	0	0	0	0	0	0
Salt Creek	0	0	31	28	31	28
Crazy Woman Creek	104	75	0	0	104	75
Clear Creek	810	948	0	0	810	948
Middle Powder River	8	7	688	564	696	571
Little Powder River	49	40	0	0	49	40
Little Missouri	0	0	0	0	0	0
Antelope Creek	4	4	0	0	4	4
Dry Fork Cheyenne	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	16	17	0	0	16	17
Middle North Platte Casper	0	0	0	0	0	0
Total	2,293	2,390	14,804	11,242	17,097	13,632

Elk

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. Table 4–85, Table 4–86, Table 4–87, and Table 4–88 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–89).

Table 4–85 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Surface Owner — Alternative 3

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	0	0	0	0	0	0	675	245	544	195	1,219	440
Parturition	0	0	0	0	0	0	342	125	61	22	403	147
Winter Yearlong	0	0	0	0	0	0	446	162	175	63	621	225
Crucial Winter Range	0	0	0	0	0	0	215	78	63	30	278	108

Table 4–86 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Sub-watershed — Alternative 3

	Disturbance (acres)							
	Year Long		Parturition		Winter Year Long		Crucial Winter Range	
Sub-watershed	Short Term	Long Term	Short Term	Long Term	Short Term	Long Term	Short Term	Long Term
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	9,530	4,363	1,567	1,567	5,324	2,438	2,338	1,072
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	9,530	4,363	1,567	1,567	5,324	2,438	2,338	1,072

Table 4–87 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Surface Owner — Alternative 3

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Year Long	50	41	28	0	0	0	88	33	244	111	410	185
Critical Winter Year Long	11	9	0	0	0	0	0	0	88	33	99	42
Critical Winter	11	9	0	0	0	0	11	9	6	5	28	23
Spring/Summer/Fall	6	5	0	0	0	0	0	0	6	5	12	10
Winter	0	0	0	0	0	0	0	0	11	9	11	9
Winter Year Long	11	9	0	0	0	0	0	0	0	0	11	9
TOTAL	89	73	28	0	0	0	99	42	354	162	571	278

Table 4–88 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Sub-watershed — Alternative 3

	Disturbance (acres)													
	Crucial Winter		Yearlong		Crucial Winter Yearlong		Spring, Summer, Fall		Winter		Winter Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	6	5	0	0	0	0	0	0	0	0	0	0	6	5
Middle Fork Powder	0	0	0	0	6	5	0	0	0	0	0	0	6	5
North Fork Powder	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder	11	9	775	288	83	28	0	0	0	0	338	122	432	159
South Fork Powder	283	103	6	5	0	0	0	0	0	0	0	0	283	103
Salt Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Clear Creek	0	0	0	0	0	0	6	5	6	5	0	0	12	10
Middle Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	17	14	0	0	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	11	9	0	0	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	300	117	808	315	89	33	6	5	12	10	338	122	745	287

Table 4–89 Elk (Fortification Creek only) Water-Handling Disturbances by Surface Owner — Alternative 3

	Year Long		Parturition		Winter Year Long		Crucial Winter Range	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance. Acres	No. of wells	H_2O Handling Disturbance acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	2,208	1,446	888	582	1,228	804	532	348
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	2,208	1,446	888	582	1,228	804	532	348

Moose

Direct and Indirect Effects

Under Alternative 3, no moose habitats would be directly or indirectly affected.

Raptors

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. The following tables present estimates of disturbance to range by surface owner and subwatershed under this alternative. These estimates include disturbances associated with water handling methods.

Water Handling

Water handling methods would not likely affect raptors directly, but may affect habitats that support prey species. Potential adverse effects of water handling facilities may include localized destruction of prey habitats and possible changes in population numbers of locally occurring prey species (e.g., small- and medium- sized mammals). Any potential effects to local prey populations would be highly localized and not expected to affect prey populations at scales relevant to predatory species, including raptors. For more information regarding potential effects to habitats, refer to the vegetation section of this chapter.

Upland Game Birds

Sage Grouse and Plains Sharp-tailed Grouse

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. The following tables present estimates of disturbance to range by surface owner and sub-watershed under this alternative. These estimates include disturbances associated with water handling methods.

Water Handling

Water handling methods would not likely affect grouse species directly, but would affect habitats that support these species. Potential adverse effects of water handling facilities may include localized destruction of nesting, feeding, and brood rearing habitats. Estimates of disturbances to vegetation types are presented in the vegetation section of this chapter.

Waterfowl

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. The following tables present estimates of disturbance to range by surface owner and sub-watershed under this alternative. These estimates include disturbances associated with water handling methods.

Cumulative Effects

Implementation of each of the alternatives would contribute to cumulative effects to big game species in the Project Area. Cumulative short- and long-term disturbance to big game species by alternative and sub-watershed are presented for each big game species. Included in this cumulative analysis are the direct effects of oil and gas (conventional and CBM) development. The Alternative 3 data do not include potential new federal wells that would be developed in response to drainage situations caused by production on adjacent state or fee minerals. Additional oil and gas development (conventional and CBM) may occur at a later date beyond the level of development considered in this analysis. Other activities contributing to cumulative effects to wildlife in the Project Area include: coal mining; uranium mining; sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban housing development.

On-going coal mining activities disturb surface lands at a rate of approximately 2,000 acres per year, with 1,850 acres successfully reclaimed on annual basis. At present, approximately 54,000 acres have been disturbed by coal mining, while 20,200 acres have been successfully reclaimed. An unknown portion of disturbed coal mining area is currently undergoing reclamation, but has not yet met success

standards. A similar level of both new disturbance and reclamation success is expected in the near future.

Uranium mining has resulted in the disturbance of approximately 4,400 acres, while sand, gravel, and scoria mining has resulted in the disturbance of approximately 1,200 acres. Agriculture has resulted in impacts to approximately 113,643 acres of lands formally occupied by native vegetation that may be suitable to wildlife. Urban development has resulted in the loss of approximately 4,362 acres of native vegetation that may be suitable wildlife habitat. A minor amount of new rural and urban development is expected in the foreseeable future but no estimate of the amount or types of vegetation disturbance has been made. Cumulative impacts to vegetation from roads, railroads, and rural development have not been estimated.

The total acreage affected by CBM development would not be disturbed simultaneously, because Project development would occur over the life of the Project. Some of the disturbed acreage would be reclaimed or would be in the process of being reclaimed when new disturbances are initiated. CBM development is expected to occur at a rate faster than abandonment and reclamation of wells. In the near future, the amount of disturbed habitats is likely to increase, although the anticipated life of CBM wells (12-20 years) indicates that reclamation would eventually overtake new well development, resulting in a net decrease in disturbed vegetation for the long-term.

Cumulative effects would also occur to vegetation resources as a result of indirect impacts. One impact is the potential import and spread of noxious weeds around Project facilities. Noxious weeds have the ability to displace native vegetation and hinder reclamation efforts. If weed mitigation and preventative procedures are applied to all construction and reclamation practices, the impact of noxious weeds would be minimized.

In areas reclaimed after CBM development, the reclaimed areas often differ substantially from undisturbed areas in terms of vegetation cover. Reclaimed areas may not serve ecosystem functions presently served by undisturbed vegetation communities and habitats, particularly in the short-term, when species composition, shrub cover, and other environmental factors are likely to be different. Establishment of noxious weeds and alternation of vegetation along drainages and reclaimed areas has the potential to alter wildlife habitat composition and distribution. As a result, shifts in habitat composition or distribution may affect wildlife species within the Project Area.

Pronghorn, White-tailed Deer, Mule Deer, and Elk

The following tables present the cumulative percentage of total big game range disturbance in the sub-watersheds for each alternative for pronghorn (Table 4–90), white-tailed deer (

Table 4–91), mule deer (Table 4–92), and elk (Table 4–93).

Table 4–90 Cumulative Habitat Loss in Sub-watersheds by Alternative for Pronghorn

	Alternative							
	1		2A		2B		3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tongue River	0.04	0.03	0.04	0.03	0.04	0.03	0.04	0.02
Middle Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Powder River	0.07	0.04	0.08	0.04	0.07	0.04	0.03	0.02
South Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salt Creek	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Crazy Woman Creek	0.04	0.02	0.04	0.02	0.04	0.02	0.01	0.01
Clear Creek	0.04	0.02	0.05	0.03	0.04	0.02	0.03	0.02
Middle Powder River	0.05	0.04	0.05	0.05	0.05	0.05	0.03	0.03
Little Powder River	0.07	0.05	0.07	0.05	0.07	0.05	0.06	0.05
Little Missouri River	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Antelope Creek	0.09	0.04	0.09	0.04	0.09	0.04	0.04	0.03
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Cheyenne River	0.03	0.02	0.04	0.02	0.03	0.02	0.02	0.02
Lightning Creek	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Upper Belle Fourche River	0.09	0.06	0.09	0.06	0.09	0.06	0.07	0.06
Middle North Casper River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.02

Table 4–91 Cumulative Habitat Loss in Sub-watersheds by Alternative for White-tailed Deer

	Alternative							
	1		2A		2B		3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tongue River	0.04	0.02	0.04	0.01	0.04	0.01	0.03	0.01
Middle Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Powder River	0.08	0.05	0.09	0.03	0.09	0.03	0.06	0.03
South Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salt Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crazy Woman Creek	0.03	0.02	0.03	0.01	0.03	0.01	0.02	0.01
Clear Creek	0.05	0.03	0.05	0.02	0.05	0.02	0.04	0.02
Middle Powder River	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Little Powder River	0.03	0.02	0.03	0.01	0.03	0.01	0.02	0.01
Little Missouri River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Antelope Creek	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lightning Creek	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00
Upper Belle Fourche River	0.04	0.03	0.04	0.01	0.04	0.01	0.03	0.01
Middle North Casper River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.04	0.01	0.04	0.01	0.03	0.01

Table 4–92 Cumulative Habitat Loss in Sub-watersheds by Alternative for Mule Deer

	Alternatives							
	1		2A		2B		3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tongue River	0.03	0.02	0.03	0.02	0.03	0.02	0.02	0.02
Middle Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Powder River	0.07	0.03	0.06	0.03	0.07	0.04	0.02	0.02
South Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salt Creek	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00
Crazy Woman Creek	0.03	0.01	0.03	0.01	0.03	0.01	0.00	0.00
Clear Creek	0.04	0.02	0.04	0.02	0.04	0.02	0.01	0.01
Middle Powder River	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.03
Little Powder River	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.03
Little Missouri River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Antelope Creek	0.05	0.02	0.05	0.02	0.05	0.02	0.01	0.01
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Cheyenne River	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01
Lightning Creek	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Upper Belle Fourche River	0.06	0.04	0.06	0.04	0.06	0.04	0.03	0.03
Middle North Casper River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.04	0.02	0.04	0.02	0.04	0.02	0.02	0.01

Table 4–93 Cumulative Habitat Loss in Sub-watersheds by Alternative for Elk (excluding Fortification Creek)

	Alternatives							
	1		2A		2B		3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tongue River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Middle Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Powder River	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.03
South Fork Powder River	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02
Salt Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crazy Woman Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clear Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Middle Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Little Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Little Missouri River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Antelope Creek	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lightning Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Belle Fourche River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Middle North Casper River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.04	0.04	0.04	0.04	0.04	0.04	0.12	0.06

Moose

Cumulative effects to the moose were not evaluated because none of the proposed alternatives directly affect moose habitat within the Project Area. Cumulative effects to existing moose habitats may occur as exploration and development of gas and mineral resources continue in the Powder River Basin. Indirect cumulative effects include the potential establishment of noxious weeds that may reduce the quantity and quality of existing moose habitats.

Raptors

Negative cumulative effects to raptors resulting from current, proposed and future activities such as gas and mineral exploration and development, agricultural activities, and urban development may include increased disturbance to nesting raptors, degradation and/or destruction of nesting habitats, increased raptor collisions with power lines and fences, increased electrocutions, and increased vehicular collisions with carrion-feeding raptors. As development brings additional power lines to the Project Area, the use of power poles as perches may be a positive effect to raptor species. This positive effect may lead to an increased hunting efficiency which, in turn, may result in higher fledging rates for nesting raptors.

Upland Game Birds

Implementation of each of the alternatives would contribute to cumulative effects to upland game birds that occur within the Project Area. These effects include increased human disturbance and physical degradation or destruction of breeding grounds (leks) and reproductive areas (nesting and brood-rearing areas).

Waterfowl

Potential negative cumulative effects may result following the implementation of each of the proposed alternatives. Negative effects would include degradation of existing nesting, feeding, and resting habitats resulting from potential increases or fluctuations in surface water levels. Positive effects would include the potential creation of suitable nesting, resting, or feeding habitats following surface containment features related to these proposed alternatives and/or future actions not addressed in this document.

Aquatic Species

For the purposes of this analysis, it is assumed that wells that discharge produced water on the surface and wells that discharge water to infiltration ponds may have potential effects on aquatic species. Water produced from wells and managed using other water handling-methods (containment, LAD, and injection) would not have effects on existing surface waters because none of the discharged water under these water handling methods would reach drainages in the subwatersheds. Therefore, these three water-handling methods will not be analyzed further.

Water handling methods were "modeled" and the models indicate that no discharged CBM water would reach mainstem rivers such as the Upper Tongue River, Powder River, Little Powder River, Cheyenne River, and Belle Fourche

River; however, for the purposes of this analysis, it is assumed that 20 percent of discharged water would reach mainstem rivers (Surface Water Quantity section). Projected annual outflows at sub-watershed boundaries are listed in Table 4–1, and annual flow characteristics at sub-watershed boundaries are listed in Table 3–5. A comparison of these two tables shows the projected increases in flow amounts by sub-watershed over the life of the Project.

The amount of water that may enter drainages below infiltration ponds due to rising water tables in shallow aquifers is unknown (Groundwater Flow section); however, if some of this water seeps into drainages, it could contribute to the surface water discharge effects discussed below.

With project adherence to NPDES permit requirements, discharges of CBM produced water to surface drainages would not likely result in violations of the Clean Water Act. The quality of produced water is not expected to noticeably affect aquatic life. NPDES permits specify water quality standards intended to protect designated uses, such as agriculture, livestock watering, and aquatic health. Therefore, water quality of receiving waters in the Powder River Basin should not be degraded to levels below aquatic life standards in tributaries and mainstems.

While containment reservoirs are expected to accumulate salts and heavy metals, they should not support fish species or macroinvertebrate populations; therefore, there should be no effect on aquatic species. Streams are not expected to accumulate salts and heavy metals to the point where aquatic species are affected. Table 3–2 shows CBM produced water quality in the PRB, including metals and salts.

Mitigation measures expected to eliminate or minimize potential effects to aquatic species are provided at the end of this chapter.

Alternative 1

Under Alternative 1, 62 percent of the proposed wells would discharge produced water on the surface and 23 percent would discharge produced water to infiltration reservoirs. Ten of eighteen sub-watersheds would receive produced water. Alternative 1 has the most proposed surface discharge of the four alternatives. Some direct/indirect effects may occur to aquatic species, assuming 20 percent of produced CBM water reaches some mainstem rivers.

Direct/Indirect Effects

Several effects of concern to aquatic species in the Project Area were considered in this analysis. Direct and indirect effects may include changes in timing and quantity of stream flows, increases and fluctuations in sedimentation, increases in concentrations of salts in streams, increasing concentrations of metals (e.g., barium, selenium), accidental spills of fuels or drilling fluids, and potential downstream trans-boundary water quality effects in Montana (Appendix B).

Timing and Quantity of Stream Flows

Stream flows are expected to increase to varying degrees in all ten sub-watersheds that would receive CBM produced water under Alternative 1 (Table

4-1). Increasing stream flows could have both positive and negative effects on aquatic species. The main positive effect would be to provide habitat to fish and macroinvertebrates in areas that are normally dry. This could provide opportunities for population growth. Increased flows may also benefit fisheries where containment and/or flow-through ponds are developed for fisheries. With proper water quality, these ponds could serve as sport fisheries or be used for breeding native species of concern.

Negative effects to fish could occur if streamflows are increased substantially, especially during spawning periods. Increased streamflows could make it difficult for certain species to migrate upstream to spawning and rearing areas, especially in reaches where manmade barriers exist (i.e. dams, water diversions). Increased flows in rearing areas may also make survival more difficult for young fish.

Groundwater depletions may impact current instream flows in isolated streams throughout the Project Area. These areas would likely be in shallow alluvium where coal seams are near the surface which could experience reductions in stream flows, but instream flows in the overall Project Area are not expected to be largely impacted by groundwater depletion because the affected aquifer is usually very deep.

Assuming that 20 percent of produced CBM from surface discharge would reach the sub-watersheds and comparing projected outflow numbers at sub-watershed boundaries (Table 4-1) to annual minimum flows (Table 3-5), the Upper Tongue River, Salt Creek, and Middle Powder River above Crazy Woman Creek would not see noticeable increases in stream flows during low flow periods. The other seven sub-watersheds may see noticeable increases in stream flows during low flow periods. These are the Upper Powder River, Crazy Woman Creek, Clear Creek, Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by the amount of surface water discharge under Alternative 1, especially during low flow periods.

Increases and Decreases in Sedimentation

Erosion rates in stream channels increase as instream flows increase, which may increase sedimentation in streams. For sub-watersheds in the Project Area, ten percent of soil loss would remain in the water flow at the point of exit from the sub-watershed (Blatt et al. 1972). Increased sedimentation can affect aquatic resources by filling interstitial (intergravel) spaces and pool habitats. This can reduce the availability of suitable spawning and rearing habitats. Aquatic macroinvertebrates are also highly dependent on interstitial spaces for different life stages, and sedimentation can cause large decreases in population numbers and change species compositions. This can be very detrimental to fisheries that are dependent on macroinvertebrates as primary food supplies and can change the abundance and diversity of fish populations.

Increased sedimentation may also reduce productivity of, or eliminate, rooted and un-rooted aquatic vegetation that many species of macroinvertebrates and fish depend on for food and habitat; this may also reduce populations of fish and macroinvertebrates. An increase of ten percent sediment load in these sub-

watersheds (Sedimentation Section, Chapter 4) may have a minor impact on fish and macroinvertebrate species and their habitats.

Because produced CBM water is relatively low in sediments, receiving waters in streams and rivers may be more turbid, resulting in decreased turbidity and sedimentation. This could be detrimental to fish species that are dependent on turbid waters, and may allow for more aggressive exotic species invasion. However, naturally occurring turbid waters are generally well downstream of CBM discharge points and turbidity would likely be at near-natural levels when entering higher turbidity waters. These effects would be minimal and isolated.

The Upper Tongue River, Salt Creek, Middle Powder River, and Upper Cheyenne River would not see noticeable increases in stream flows or increased sedimentation and impacts to aquatic species would be minimal or non-existent. The other six sub-watersheds may see noticeable increases in stream flows during low flow periods that may noticeably increase sediment loads in these watersheds. These are the Upper Powder River, Crazy Woman Creek, Clear Creek, Little Powder River, Antelope Creek, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by an increase in sedimentation.

The proposed addition of over 17,000 miles of new roads within the Project Area would lead to additional sedimentation in drainages in all sub-watersheds within the Project Area. Roads allow for increased runoff that leads to increased sedimentation. Increased sedimentation resulting from roads would be most noticeable during storm events, including wind blowing dust off of roads which may enter drainage systems.

Increases and Decreases in Salt Concentrations

Increases in salt concentrations can alter the algae and macroinvertebrate composition of streams and, if sufficiently elevated, can alter the abundance and diversity of fish species. Projected CBM produced water has salinities that differ from the existing receiving waters in the ten sub-watersheds (surface water quality section in chapter 4). Salinity in receiving waters is predicted to increase slightly in the Upper Tongue River, Upper Powder River, Crazy Woman Creek, Clear Creek, Middle Powder River, and Antelope Creek sub-watersheds. Salinity is expected to decrease slightly in the Little Powder River, Upper Cheyenne River, and Upper Belle Fourche River sub-watersheds. Salinity in Salt Creek will remain unchanged. A substantial decrease in salinity (20 percent) in the Upper Belle Fourche River sub-watershed is predicted; this may affect fish and macroinvertebrate species, but may be beneficial to native species. The salinity in the remaining eight sub-watersheds would change by less than ten percent. Aquatic species may experience minor effects from the predicted changes in salinity, but population dynamics should not be affected.

A recent study by the Montana Fish, Wildlife, and Parks (Skaar 2001) described concerns relating to sodium bicarbonate toxicity to aquatic life in the Powder and Tongue Rivers. The study suggests that bicarbonate levels should be monitored for their potential effects on aquatic life, especially fish. Low, moderate, and high probability thresholds were modeled for each river to determine lethal limits to the fathead minnow; these limits can then be generally applied to many fish spe-

cies. Limits were established at 530 mg/L to meet the low probability threshold, 1000 mg/L to meet the moderate threshold, and 1475 mg/L to meet the high threshold in the Tongue River near Miles City, Montana. They were established at 400 mg/L, 870 mg/L, and 1340 mg/L, respectively, for the Powder River near Locate, Montana. These established thresholds could be used to initiate a monitoring program for bicarbonate in all ten sub-watersheds that receive CBM produced water. Refer to Table 3-2 for measured bicarbonate levels in CBM produced waters within the Project Area. Fish and macroinvertebrates could be negatively impacted by elevated bicarbonate levels in the receiving sub-watersheds. Concentrations of bicarbonate are generally higher during low flow periods, and lower during high flow periods, resulting in greater accumulations and greater effects on aquatic life during low flow periods.

In addition to salts being added directly to surface drainages, CBM produced waters that do not reach drainages will evaporate and deposit salts in soils throughout the sub-watersheds. This accumulation of salts in the soils will continue as long as CBM produced water is discharged, and may be released into surface drainages and groundwater for years after the discharge of water ceases, further increasing salinity in surface drainages and potentially affecting fish and macroinvertebrates.

Increases in Metals

CBM produced water within the Project Area has been shown to contain low levels of metals such as selenium (Table 3-2). Effects of selenium on fish may range from physical malformations during embryonic development to sterility and death (Lemly and Smith 1987). Concentrations greater than 2 to 5 µg/L in water can cause reproductive failure or mortality in fish due to foodchain bioaccumulation (Lemly and Smith 1987). Selenium can be absorbed or ingested by organisms, can bind to particulate matter, or can remain free in solution. Most of it usually accumulates in the top layer of sediment and detritus. Selenium can then be cycled back into the biota and remain elevated for years after selenium input has stopped (Lemly and Smith 1987). Generally, flowing waters accumulate less selenium than do standing waters that have low flushing rates and recovery is much slower in shallow impoundments and wetlands than in fast-flowing rivers and streams (Lemly and Smith 1987).

Levels of selenium in CBM produced water in the Project Area are much lower than the specified level of concern. Water quality was analyzed in six sub-watersheds, and selenium was undetected in CBM produced water in the Antelope Creek and the Upper Cheyenne River sub-watersheds. Selenium was detected in CBM produced water in the Upper Powder River, Middle Powder River, Little Powder River, and Upper Belle Fourche River sub-watersheds. The highest mean selenium concentration within these sub-watersheds was 0.83 µg/L (Table 3–2), which is below hazardous levels to fish. Concentrations of selenium are generally higher during low flow periods, and lower during high flow periods, resulting in greater accumulations during low flow periods.

Although selenium concentrations were measured below hazardous limits, bioaccumulation of selenium may increase as more selenium is introduced into the ecosystem. Levels of selenium could reach dangerous levels for fish over the life of the Project. It is anticipated that containment ponds and reservoirs would have

a much higher probability of achieving hazardous levels of selenium than do the stream and river systems within the ten sub-watersheds in the Project Area. Fish and macroinvertebrate species that may exist in ponds and reservoirs that receive CBM produced water may experience effects from selenium bioaccumulation. Fish and macroinvertebrate species in stream and river systems within the ten sub-watersheds may be impacted by increased selenium input.

Fuel and Drilling Fluid Spills

Fuel and drilling fluid spills can result in fish and macroinvertebrate kills and degradation of habitat. The severity and scope of a stream kill would depend upon the volume spilled, distance of the spill from surface water, and the chemical and toxicological properties of the spilled materials.

Increases or Decreases in Species Diversity

Changes in flow, sedimentation and turbidity, and water quality (including salinity and metals) could all potentially affect fish and macroinvertebrate species diversity, especially if these conditions remain changed for a long period. The longer the duration for CBM produced waters entering drainages, the greater the probability there would be of it affecting species diversity over larger portions of drainages.

Trans-boundary Water Quality Effects

The states of Wyoming and Montana have developed an Interim Water Quality Criteria MOC that states that water quality in streams and rivers entering Montana from Wyoming will not exceed set limits for toxicity due to CBM produced water being discharged in Wyoming. Sufficient mitigation measures would be in place to ensure that water quality would not be degraded substantially at the Wyoming/Montana border (Appendix B).

Alternative 2A

Under Alternative 2A, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Alternative 2A involves different water handling of the produced water in certain sub-watersheds, emphasizing discharge of CBM water to infiltration impoundments. Approximately 25 percent of the proposed wells would discharge produced water on the surface and 51 percent would discharge produced water to infiltration reservoirs. Thus, the volume of water discharged to surface drainages would be less than under Alternative 1 and is shown in Table 4-1. Projected CBM runoff compared with average annual runoff is shown in Table 4-2. Ten of eighteen sub-watersheds would receive produced water under this alternative.

Direct/Indirect Effects

Water quality effects would be similar to those described for Alternative 1, but proportionately lower due to the reduction in the volume of produced water being discharged to surface drainages.

Timing and Quantity of Stream Flows

CBM supplemented flows would increase slightly from baseline conditions under Alternative 2A, and the projected annual outflow of CBM produced water at the sub-watershed boundaries would be much less than under Alternative 1, as shown in Table 4–1.

Comparing projected outflow numbers at sub-watershed boundaries (Table 4–1) to annual minimum flows (Table 3-5), the Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, Clear Creek, and Middle Powder River would not see noticeable increases in stream flows during low flow periods. The other four sub-watersheds may see noticeable increases in stream flows during low flow periods. These are the Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above under Alternative 1; however, the degree to which they may be impacted would be substantially less under Alternative 2A than under Alternative 1.

Increases and Decreases in Sedimentation

Due to less CBM produced water being discharged to surface drainages under Alternative 2A, the degree to which sedimentation would occur in rivers and streams would be significantly less than under Alternative 1, although the types of potential impacts would be similar.

The Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, Clear Creek, Middle Powder River, and Upper Cheyenne River would not see noticeable increases in stream flows during low flow periods or increased sedimentation, and impacts to aquatic species would be minimal or non-existent. The other three sub-watersheds may see noticeable increases in stream flows during low flow periods that may noticeably increase sediment loads in these watersheds. These are the Little Powder River, Antelope Creek, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by an increase in sedimentation, but impacts would likely be noticeably less than under Alternative 1.

Increases and Decreases in Salt Concentrations

Changes in salt concentrations in surface waters receiving CBM produced water would also be less under Alternative 2A than under Alternative 1, although the types of potential impacts would be similar. Salinities may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 2A. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 2A.

Increases in Metals

Changes in metal concentrations in surface waters receiving CBM produced water would also be less under Alternative 2A than under Alternative 1, although the types of potential impacts would be similar. Metal concentrations may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 2A. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 2A.

Fuel and Drilling Fluid Spills

Potential fuel and drilling fluid spills would likely result in less of an impact to fish and macroinvertebrates under Alternative 2A than under Alternative 1 because there would be less CBM produced water available to convey pollutants to surface drainages.

Increases or Decreases in Species Diversity

Potential changes in species diversity would be similar to Alternative 1 under Alternative 2A, although they would occur at a lesser degree.

Alternative 2B

Under Alternative 2B, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Alternative 2B involves different water handling of the produced water in certain sub-watersheds, emphasizing surface discharge of CBM water and discharge to infiltration impoundments. Approximately 40 percent of the proposed wells would discharge produced water on the surface and 37 percent would discharge produced water to infiltration reservoirs. Thus, the volume of water discharged to surface drainages would be less than under Alternative 1 but more than under Alternative 2B, and is shown in Table 4–1. Projected CBM runoff compared with average annual runoff is shown in Table 4–2. Ten of eighteen sub-watersheds would receive produced water.

Direct/Indirect Effects

Water quality effects would be similar to those described for Alternative 1, but proportionately lower due to the reduction in the volume of produced water being discharged to surface drainages.

Timing and Quantity of Stream Flows

Flows supplemented by CBM produced water would increase slightly from baseline conditions under Alternative 2B, and the projected annual outflow of CBM produced water at the sub-watershed boundaries would be less than under Alternative 1, with one exception (Table 4–1). Flow in the Upper Belle Fourche would increase above the predicted flow under Alternative 1 by approximately 32 percent.

Comparing projected outflow numbers at sub-watershed boundaries (Table 4–1) to annual minimum flows (Table 3–5), the Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, and Middle Powder River would not see noticeable increases in stream flows during low flow periods. The other five sub-watersheds may see noticeable increases in stream flows during low flow periods. These are Clear Creek, the Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above under Alternative 1; however, the degree to which they may be impacted would be substantially less under Alternative 2B than under Alternative 1, except in the Upper Belle Fourche River where impacts may be greater than predicted under Alternative 1.

Increases and Decreases in Sedimentation

Due to less CBM produced water being discharged to surface drainages under Alternative 2B, the degree to which sedimentation would occur in rivers and streams would be substantially less than under Alternative 1, although the types of potential impacts would be similar.

The Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, Clear Creek, Middle Powder River would not see noticeable increases in stream flows during low flow periods or increased sedimentation, and impacts to aquatic species would be minimal or non-existent. The other four sub-watersheds may see noticeable increases in stream flows during low flow periods that may noticeably increase sediment loads in these watersheds. These are the Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by an increase in sedimentation, but impacts would likely be noticeably less than under Alternative 1.

Increases and Decreases in Salt Concentrations

Changes in salt concentrations in surface waters receiving CBM produced water would also be less under Alternative 2B than under Alternative 1, although the types of potential impacts would be similar. Salinities may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 2B. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 2B than under Alternative 1.

Increases in Metals

Changes in metal concentrations in surface waters receiving CBM produced water would also be less under Alternative 2B than under Alternative 1, although the types of potential impacts would be similar. Metal concentrations may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 2B, with the exception of the Upper Belle Fourche River, where affects would be more substantial. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 2B.

Fuel and Drilling Fluid Spills

Potential fuel and drilling fluid spills would likely result in less of an impact to fish and macroinvertebrates under Alternative 2B than under Alternative 1 because there would be less CBM produced water available to convey pollutants to surface drainages, with the exception of the Upper Belle Fourche River.

Increases or Decreases in Species Diversity

Potential changes in species diversity would be similar to Alternative 1 under Alternative 2B, although they would occur at a lesser degree.

Alternative 3

Under Alternative 3, no new Federal CBM wells would be completed. Water handling options would be the same as under Alternative 1. Water production would decline under Alternative 3. Thus, the volume of water discharged to sur-

face drainages would be less than under Alternatives 1, 2A, and 2B as shown in Table 4–1. Projected CBM runoff compared with average annual runoff is shown in Table 4–2. Ten of eighteen sub-watersheds would receive produced water.

Direct/Indirect Effects

Water quality effects would be similar to those described for Alternative 1, but proportionately lower due to the reduction in the volume of produced water being discharged to surface drainages. Water quality changes due to CBM enhanced flows would be negligible (surface water section in Chapter 4).

Timing and Quantity of Stream Flows

Flows supplemented by CBM produced water would increase slightly from baseline conditions under Alternative 3, and the projected annual outflow of CBM produced water at the sub-watershed boundaries would be less than under Alternative 1 (Table 4–1).

Comparing projected outflow numbers at sub-watershed boundaries (Table 4–1) to annual minimum flows (Table 3–5), the Upper Tongue River, Upper Powder River, Salt Creek, and Middle Powder River would not see noticeable increases in stream flows during low flow periods. The other six sub-watersheds may see noticeable increases in stream flows during low flow periods. These are Crazy Woman Creek, Clear Creek, Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above under Alternative 1; however, the degree to which they may be impacted would be substantially less under Alternative 3 than under Alternative 1.

Increases and Decreases in Sedimentation

Due to less CBM produced water being discharged to surface drainages under Alternative 3, the degree to which sedimentation occurs in rivers and streams would be substantially less than under Alternative 1, although the types of potential impacts would be similar.

The Upper Tongue River, Upper Powder River, Salt Creek, and Middle Powder River would not see noticeable increases in stream flows during low flow periods or increased sedimentation, and impacts to aquatic species would be minimal or non-existent. The other six sub-watersheds may see noticeable increases in stream flows during low flow periods that may noticeably increase sediment loads in these watersheds. These are the Crazy Woman Creek, Clear Creek, Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by an increase in sedimentation, but impacts would be noticeably less than under Alternative 1.

Increases and Decreases in Salt Concentrations

Changes in salt concentrations in surface waters receiving CBM produced water would also be less under Alternative 3 than under Alternative 1, although the types of potential impacts would be similar. Salinities may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 3.

Related impacts to fish and macroinvertebrates would therefore be less under Alternative 3 than under Alternative 1.

Increases in Metals

Changes in metal concentrations in surface waters receiving CBM produced water would also be less under Alternative 3 than under Alternative 1, although the types of potential impacts would be similar. Metal concentrations may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 3. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 3.

Fuel and Drilling Fluid Spills

Potential fuel and drilling fluid spills would likely result in less of an impact to fish and macroinvertebrates under Alternative 3 than under Alternative 1 because there would be less CBM produced water available to convey pollutants to surface drainages.

Increases or Decreases in Species Diversity

Potential changes in species diversity would be similar to Alternative 1 under Alternative 3, although they would occur at a lesser degree.

Cumulative Effects

Implementation of each of the alternatives would contribute to cumulative effects on aquatic species in the Project Area. The proposed alternatives, combined with the potential for future CBM projects not addressed in this document, may lead to potential cumulative effects including fluctuations in stream flow, fluctuations in sedimentation, increases in salt concentrations, changes in water quality, increases in contaminants in waterways, changes in habitats, and changes in species diversity. Each alternative would contribute to cumulative effects in varying degrees, as discussed in the aquatic effects section.

Current major land uses in the Project Area include livestock grazing, agriculture, mining, CBM gas development, and conventional oil and gas development. The proposed Project would contribute to ongoing effects to aquatic life from all of these land uses.

In addition to an increase in flow in sub-watersheds that receive CBM produced waters, coal mines in the Project Area discharge water from pits into surface drainages. Coal mine records for activities within the Project Area indicate that water is generally discharged from pits only after storm events, at which time water quality in receiving waters is similar to discharge water. This would not affect sedimentation or water quality to a large degree, but would add to already increased instream flows during high runoff periods. Watersheds within the Project Area that have existing coal mines include Upper Cheyenne River, Upper Belle Fourche River, and Little Powder River. These cumulative impacts would affect aquatic species in the same ways as discussed above. After CBM development is completed, flows would return to the current flow regime.

The proposed Project would lead to an overall increase in sediment load in drainages within the Project Area and would contribute to increased sedimentation caused by the existing land uses in the area. Increased CBM produced flow and sedimentation related to the construction of new roads would be the primary contributor to increased sediment load in the drainage systems. Much of the sediment produced by the Project would be collected in ponds and reservoirs throughout the Project Area, and would likely be flushed through the drainage systems for years after the discharge of CBM water. Increased sediment load may also change or eliminate existing fish and macroinvertebrate habitats over the long term; these changes in habitat may favor exotic species over native species.

In addition to salts being added directly to surface drainages, CBM produced waters that do not reach drainages (e.g., containment, LAD, and injection) will evaporate and deposit salts in soils throughout the sub-watersheds. This accumulation of salts in the soils will continue as long as CBM produced water is discharged, and may be released into surface drainages and groundwater for years after the discharge of water ceases, further increasing salinity in surface drainages and potentially affecting fish and macroinvertebrates. Agriculture and livestock grazing are currently the primary sources of salt introduction, and CBM produced waters would contribute additional salts.

Water quality would continue to change throughout the Project Area both during and after the life of the Project, and would continue to affect aquatic life in drainages already affected by existing land uses. Long-term water quality effects that would likely continue after CBM wells cease water discharge include increased concentrations of selenium, bicarbonate and other salts, and sediment load; these could all potentially affect aquatic life.

All of the cumulative effects may influence current fish and macroinvertebrate species diversities. Long-term cumulative effects may alter water quality and fish habitats to the extent that exotic species can utilize these streams and rivers more effectively than native species, resulting in more exotic species and less native species.

Alternative 1

Under Alternative 1, cumulative effects would be highest in the Powder River Basin, including the Upper Powder River, Salt Creek, Crazy Woman Creek, and Clear Creek, followed by the Upper Tongue River, Upper Belle Fourche River, Upper Cheyenne River including Antelope Creek, Little Powder River, and Middle Powder River, respectively. This conclusion is based on the increase in surface water flows due to CBM produced water discharge and effects associated with these discharges that would contribute to cumulative effects. Alternative 1 would have the most cumulative impacts of the four alternatives.

The development of new roads would also contribute to cumulative effects in watersheds that will not receive discharged CBM water.

Alternative 2A

Under Alternative 2A, cumulative effects would be highest in the Powder River Basin, including the Upper Powder River, Crazy Woman Creek, and Clear Creek, followed by the Upper Belle Fourche River, Upper Tongue River, Upper Cheyenne River including Antelope Creek, Little Powder River, and Middle Powder River, respectively. This conclusion is based on the increase in surface water flows due to CBM produced water discharge and effects associated with these discharges that would contribute to cumulative effects. Alternative 2A would have more cumulative impacts than Alternative 3, but less than Alternatives 1 and 2B.

The development of new roads would also contribute to cumulative effects in watersheds that will not receive discharged CBM water.

Alternative 2B

Under Alternative 2B, cumulative effects would be highest in the Powder River Basin, including the Upper Powder River, Crazy Woman Creek, and Clear Creek, followed by the Upper Belle Fourche River, Upper Tongue River, Upper Cheyenne River including Antelope Creek, Little Powder River, and Middle Powder River, respectively. This conclusion is based on the increase in surface water flows due to CBM produced water discharge and effects associated with these discharges that would contribute to cumulative effects. Alternative 2B would have more cumulative impacts than Alternatives 2A and 3, but less than Alternative 1.

The development of new roads would also contribute to cumulative effects in watersheds that will not receive discharged CBM water.

Alternative 3

Under Alternative 3, cumulative effects would be highest in the Powder River Basin, including the Upper Powder River, Crazy Woman Creek, and Clear Creek, followed by the Upper Belle Fourche River, Upper Tongue River, Little Powder River, Upper Cheyenne River including Antelope Creek, and Middle Powder River, respectively. This conclusion is based on the increase in surface water flows due to CBM produced water discharge and effects associated with these discharges that would contribute to cumulative effects. Alternative 3 would have the least amount of cumulative effects of all the alternatives.

The development of new roads would also contribute to cumulative effects in watersheds that will not receive discharged CBM water.

Threatened, Endangered, and Sensitive Species

Potential effects to special status species would be similar to those described for vegetation and wildlife species. The nature and extent of effects to a particular species would depend on that species' life history and habitats utilized. Direct effects to special status plant species would occur from the disturbance or removal of individuals or populations resulting from the construction of well pads, compressor stations, ancillary facilities, associated pipelines, water-handling facilities, and roads. Indirect effects to special status plant species would include: 1) an increase in the potential for spread of noxious weeds that displaces native plant populations, due to increased disturbance in the Project Area; and 2) alteration of suitable habitat distribution, due to changes in volume and rate of surface water flows, particularly changes in stream flow from intermittent to perennial.

Effects to special status wildlife species would include: 1) disturbance effects on individuals and populations by human activity; 2) the loss or reduction in effectiveness of habitats occupied by these species; 3) habitat fragmentation, particularly through construction of roads, well pads, and fences; 4) introduction of new perches for raptors and thus potential increase in local predation rates on some species; 5) increases in harassment; and 6) project-induced increase in mortality (e.g., poaching, trapping, poisoning, roadkills, raptor collision, raptor electrocution). The magnitude of effects to special status species would depend on a number of factors, including recommended and required mitigation measures.

Direct disturbance of special status species habitats would occur in each subwatershed and under each alternative. In an effort to return habitats to full use, unused portions of well sites would be reclaimed during the production phase. Following the end of the production phase, well field and ancillary facilities would be removed and disturbed areas reclaimed. Seed mixes approved by the appropriate agency, many of which are intended to be beneficial to wildlife species, would be used to revegetate abandoned well pads and areas occupied by ancillary facilities. The amount of time these lands are unsuitable as habitats is variable and may depend on one or more of the following: productive well lifespan, mitigation success, reclamation techniques, and local weather conditions. Reclamation of habitats dominated by grasses and forbs is expected to be successful within several years; habitats dominated by shrubs and trees may take eight to twenty years or more to successfully re-establish. Consequently, the disturbance of forest and shrub habitats would represent a long-term loss to those species that depend on such vegetation for forage or shelter beyond the end of the production phase.

Indirect effects, including displacement, would occur in varying degrees during construction, production, and reclamation phases of the Project. In response to the increased levels of human activity, equipment operation, vehicular traffic, and noise associated with all phases of the Project, species would avoid areas of these activities and utilize other locations. This avoidance would result in the under-utilization of otherwise suitable habitats; therefore the value of these habitats would be diminished. Additionally, distribution patterns would be altered and resource competition would be increased in unaffected habitats. The degree of

habitat avoidance would vary among species and among individuals of any particular species.

Mitigation measures expected to eliminate or minimize potential effects to threatened and endangered wildlife and plant species are provided at the end of this chapter. Additionally, the Biological Assessment for species listed or proposed for listing by the USFWS is included as Appendix H.

Plant Species

U. S. Fish and Wildlife Service

Ute Ladies'-tresses Orchid

Direct and Indirect Effects

The potential for direct effects to this species would be minimal. There are no existing oil and gas wells in the upper portion of the Antelope Creek subwatershed near the known population occurrence of this species. None of the wells that are proposed as a part of this Project would be constructed near that location. There is the potential for other populations of this species to occur in the Project Area. Prior to construction, surveys of suitable habitats (i.e., wetlands and riparian areas) would be required. In addition, efforts would be made to avoid habitats suitable for this species. Because of the ability of this species to persist below-ground or above-ground without flowering, single season surveys that meet the current USFWS survey guidelines may not detect populations. As a result, part or all of undetected populations could be lost to surface-disturbing activities.

Indirect effects to currently undocumented populations of this species would occur as a result of hydrological alterations associated with the Project. The discharge of produced water would potentially alter the distribution and extent of riparian and wetland areas, with the net effect being an increase in the extent of these areas. This may provide additional suitable habitat for the Ute ladies'-tresses orchid in areas that are not currently suitable, while at the same time rendering unsuitable some habitat that is currently suitable. Groundwater depletion associated with CBM well de-watering could result in lowered water tables and loss of riparian and wetland vegetation in isolated area where the coal seams are near shallow alluviums. In some conditions, groundwater levels may be supplemented and not depleted following applied water handling methods. Increased groundwater levels may augment existing orchid habitats or create new suitable habitats. Effects along any particular drainage would depend on the amount, timing, and location of water discharge, stream geomorphology, precipitation, and other factors. Habitats and populations of this species may be affected by increased erosion or sediment deposition. Some streams would be greatly affected by discharge, while others would be affected only minimally or not at all.

Both direct and indirect disturbances to populations and habitats of the Ute ladies'-tresses orchid have the potential to increase the distribution and extent of noxious weeds, such as Canada thistle, that occur in similar habitats as this spe-

cies. Dense populations of noxious weeds reduce the amount of habitat available to the orchid and could result in the exclusion of the orchid from infested areas.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar numbers of CBM and non-CBM wells. Therefore, potential effects to the Ute ladies'-tresses orchid as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of 15,458 CBM wells and 1,409 Non-CBM wells, potentially affecting the Ute ladies'-tresses orchid to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 14,384 acres that could potentially affect the Ute ladies'-tresses orchid, which is also less than the other three alternatives.

Wildlife Species

U. S. Fish and Wildlife Service

Black-tailed Prairie Dog

Direct and Indirect Effects

The Project would have both direct and indirect effects on individuals and populations of the black-tailed prairie dog. Individuals and colonies would be impacted by construction of well pads, roads, pipelines, and other facilities. Increased availability of perches for raptor species would increase predation on prairie dogs. Fragmentation would reduce habitat availability in colonies, reducing habitat quality and reproductive potential in areas that are close to, or at, carrying capacity. Increased vehicle traffic would increase the potential for vehicle collisions, reducing population levels in colonies adjacent to existing and new roads. Shifts in vegetation types as a result of produced water discharges would reduce the amount of habitats available for burrows because prairie dogs do not dig burrows in wet or saturated soils. Expanded wetland and riparian areas within colonies would increase fragmentation and decrease habitat effectiveness.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar numbers of CBM and non-CBM wells. Therefore, potential effects to the black-tailed prairie dog as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of fewer CBM non-CBM wells, thus potentially affecting the black-tailed prairie dog to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in

the disturbance of 13,870 acres that could potentially affect the black-tailed prairie dog, which is also less than the other three alternatives.

Preble's Meadow Jumping Mouse

Direct and Indirect Effects

This species would not be affected by the Project because it does not occur in parts of the Project Area that would be impacted by development. Discharge of produced water to the North Platte River is expected to be minimal and would not affect the overall hydrologic regime of this large river system.

Alternative Comparisons

None of the alternatives would affect the Preble's meadow jumping mouse.

Black-footed Ferret

Direct and Indirect Effects

The potential for effects to the black-footed ferret are expected to be minimal. There are no known populations of this species in the Project Area. Most of the larger prairie dog colonies thought to be capable of supporting ferret populations have been surveyed to rule out presence of the ferret. Any colonies that meet the USFWS guidelines for potential black-footed ferret habitat that have not been previously surveyed would be surveyed for ferrets. No activities would occur in any colonies found to contain ferrets.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar numbers of CBM and non-CBM wells. Therefore, potential effects to suitable black-footed ferret habitat as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of fewer CBM and non-CBM wells, potentially affecting suitable black-footed ferret habitat to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 14,384 acres that could potentially affect suitable black-footed ferret habitat, which is also less than the other three alternatives.

Bald Eagle

Direct and Indirect Effects

Bald eagles may be impacted in several ways. Changes in the availability of water and forage due to the Project activities may result in increased or new wildlife populations, such as big game, small mammals, upland birds, waterfowl, and passerines. An increase in wildlife populations within the Project Area, combined with the increase in volume and frequency of vehicular traffic, may result in an increase of vehicular collisions and roadside carcasses. Because bald eagles often

forage on carcasses, a potential increase in carcasses may result in an increase of bald eagle foraging along roads within the Project Area. As the number of potential carcasses increases and the number of foraging eagles increases, so does the potential for vehicular collisions with bald eagles foraging on roadside carcasses.

New and additional levels of human disturbance in an area relatively void of human disturbance may have a negative effect to nesting and wintering bald eagles in the Project Area. Due to the current relative lack of human activity, bald eagles may exhibit sensitivities to activities of short duration and extent that would not otherwise affect bald eagles of other landscapes that are more accustomed to disturbance.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar number of CBM and non-CBM wells. Therefore, potential effects to the bald eagle as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of fewer CBM and non-CBM wells, potentially affecting the bald eagle to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 14,384 acres that could potentially affect the bald eagle, which is also less than the other three alternatives.

Mountain Plover

Direct and Indirect Effects

The Project has the potential to have substantial adverse direct and indirect effects to the mountain plover. Direct loss of individuals and nests may occur as a result of vehicle collision and equipment operation in nesting areas. Chicks and eggs in nests may also be lost if disturbance or harassment occurs frequently, preventing adults from tending to chicks or nests and allowing excessive heating, chilling, or predation to occur. Frequent disturbance may lead to nest abandonment. Re-nesting may occur at another, less disturbed location, but a net loss in reproductive potential would have occurred with loss of the initial nest. Mountain plovers also show a high rate of nest site fidelity, often using the same general area year after year. Modifications that make these sites less suitable for nesting would result in decreased reproductive success. New nests may be placed in less suitable habitat, again resulting in potentially lower reproductive success.

Preferred nesting habitats, such as bare soil, may be created by construction and production activities. While providing habitat, these areas are also likely to result in nests being abandoned or destroyed when activities continue during the nesting season. The potential for this type of impact to occur would be greatest during the production phase, when limited intermittent activity would occur at well pads and along some access roads. Mountain plovers may arrive and begin nesting on bare ground in these areas, only to be disturbed or have nests destroyed the next time the road is used or well pad visited. This impact is most likely when

activities occur at an interval of one week or more. During the construction phase, continuous activity is likely to prevent nest establishment in proximity to activities.

Indirect effects to mountain plovers would be caused by increased predator populations, especially of species that sometimes increase in areas impacted by humans, such as corvids (crows, ravens), raptors, coyotes, badgers, weasels, and foxes. New fences, transmission lines, and buildings would provide new perch and nest sites for avian predators, while buildings and other facilities would provide new denning sites for mammalian predators. Increased roadkills along new and existing roads would provide a food source that would allow increased predator populations that could also prey on mountain plovers.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar numbers of CBM and non-CBM wells. Therefore, potential effects to the mountain plover as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of fewer CBM and non-CBM wells, potentially affecting the mountain plover to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 14,384 acres that could potentially affect the mountain plover, which is also less than the other three alternatives.

Boreal Western Toad

Direct and Indirect Effects

This species would not be affected by the Project because it is not known to occur, nor is it expected to occur, in the Project Area. Historically occupied habitats are all outside of the Project Area a substantial distance to the south and much higher in elevation. Potential indirect effects to this non-migratory species are not expected. Hydrological alterations would not occur do to the lack of hydrologic interconnection between the Project Area and suitable habitats for this species.

Alternative Comparisons

None of the alternatives would affect the boreal western toad.

Wyoming BLM and Forest Service

Many of the BLM and Forest Service Sensitive species that occur in the Project Area may be affected by the proposed Project. The extent of effects to any particular species are dependent on its life history, habitat preferences, adaptability to disturbance, and population levels in the portion of the Project Area that would be affected by the proposed Project. Because population levels of many sensitive species in the Project Area are unknown, and because the relationship between occupied areas and proposed Project activities are unknown, only the general types and levels of impacts can be determined. Table 4–94 lists the potential im-

pacts of the proposed Project on each species and gives an estimate of the effect of these impacts on populations. Any identified mitigation measures for sensitive species are also listed in Table 4–94.

Cumulative Effects

Implementation of each of the alternatives would contribute to cumulative effects to both TES plant and wildlife species in the Project Area. One factor in the cumulative short- and long-term disturbance to TES plant and wildlife species would result from the direct effects of oil and gas (conventional and CBM) development. Additional oil and gas development (conventional and CBM), not included as part of this assessment, may also occur at a later date beyond the level of development considered in this analysis. Other activities contributing to cumulative effects to TES plant and wildlife in the Project Area include: coal mining; uranium mining; sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban housing development.

On-going coal mining activities disturb surface lands at a rate of approximately 2,000 acres per year, with 1,850 acres successfully reclaimed on an annual basis. At present, approximately 54,000 acres have been disturbed by coal mining, while 20,200 acres have been successfully reclaimed. An unknown portion of disturbed coal mining area is currently under-going reclamation, but has not yet met success standards. A similar level of both new disturbance and reclamation success is expected in the near future. It is not known at this time which TES plant and wildlife species may be affected by this development.

Uranium mining has resulted in the disturbance of approximately 4,400 acres, while sand, gravel, and scoria mining has resulted in the disturbance of approximately 1,200 acres. Agriculture has resulted in impacts to approximately 113,643 acres of lands formally occupied by native vegetation that may be suitable to TES plants and wildlife. Urban development has resulted in the loss of approximately 4,362 acres of native vegetation that may be suitable TES plant and wildlife habitat. A minor amount of new rural and urban development is expected in the foreseeable future but no estimate of the amount or types of vegetation disturbance has been made. Cumulative impacts to vegetation from roads, railroads, and rural development have not been estimated.

Table 4–94 Wyoming BLM and Forest Service Sensitive Species Effects Evaluation

Species Name	Potential Effects	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Plants					
Laramie Columbine	Not known to occur in project area.	No effect	No effect	No effect	No effect
Porter's Sagebrush	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Nelson's Milkvetch	Individual plants may be destroyed during development and production activities. Entire occurrences are unlikely to be destroyed.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Many-stemmed Spider-flower	Not known to occur in project area.	No effect	No effect	No effect	No effect
Wouldiams' Wafer-parsnip	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Cary Beardtongue	Not known to occur in project area.	No effect	No effect	No effect	No effect
Laramie False-sagebrush	Not known to occur in project area.	No effect	No effect	No effect	No effect
Soft Aster	Not known to occur in project area.	No effect	No effect	No effect	No effect
Northern Arnica	Not known to occur in project area.	No effect	No effect	No effect	No effect
Hall's Fescue	Not known to occur in project area.	No effect	No effect	No effect	No effect
Northern Blackberry	Not known to occur in project area.	No effect	No effect	No effect	No effect
Hapeman's Sullivantia	Not known to occur in project area.	No effect	No effect	No effect	No effect
Mammals					
Dwarf Shrew	Not known to occur in project area.	No effect	No effect	No effect	No effect
Long-eared Myotis	Habitat may be altered. Roost sites may be disturbed. Foraging individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Fringed Myotis	Habitat may be altered. Roost sites may be disturbed. Foraging individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Townsend's Big-eared Bat	Habitat may be altered. Roost sites may be disturbed. Foraging individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Spotted Bat	Not known to occur in project area.	No effect	No effect	No effect	No effect
White-tailed Prairie Dog	Habitats may be altered or lost. Colonies may be fragmented. Individuals may be destroyed by construction and production related activities. Raptor predation may increase	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Water Vole	Not known to occur in project area.	No effect	No effect	No effect	No effect
Wolverine	Not known to occur in project area.	No effect	No effect	No effect	No effect
Swift Fox	Habitats may be altered, lost, or fragmented. Denning sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
American Marten	Not known to occur in project area.	No effect	No effect	No effect	No effect
Least Weasel	Habitats may be altered, lost, or fragmented. Denning sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Birds					
American Peregrine Falcon	Habitats may be altered. Nest sites may be disturbed. Foraging individuals	May affect[1]	May affect[1]	May affect[1]	May affect[1]

Table 4–94 Wyoming BLM and Forest Service Sensitive Species Effects Evaluation

Species Name	Potential Effects	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
	may be disturbed by development or production activities.				
American Bittern	Habitats may be altered by changes in hydrologic regime. Nest sites may be disturbed. Individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
White-faced Ibis	Habitats may be altered by changes in hydrologic regime. Nest sites may be disturbed. Individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Trumpeter Swan	Habitats may be altered by changes in hydrologic regime. Nest sites would not be disturbed. Individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Northern Goshawk	Habitats would not be affected, because no activities would occur in occupied portion of project area.. Nest sites would not be disturbed. Individuals that move into affected portion of project area may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Merlin	Habitats may be altered. Nest sites may be disturbed. Foraging individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Upland Sandpiper	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Long-billed Curlew	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Yellow-billed Cuckoo	Habitats may be altered by changes in hydrologic regime. Nest sites may be disturbed. Individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Burrowing Owl	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Lewis' Woodpecker	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Three-toed Woodpecker	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Loggerhead Shrike	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Golden-crowned Kinglet	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Pygmy Nuthatch	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Sage Thrasher	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Sage Sparrow	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed.	May affect[2]	May affect[2]	May affect[2]	May affect[2]

Table 4–94 Wyoming BLM and Forest Service Sensitive Species Effects Evaluation

Species Name	Potential Effects	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
	Individuals may be destroyed by construction and production related activities.				
Baird's Sparrow	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Brewer's Sparrow	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Grasshopper Sparrow	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Amphibians					
Northern Leopard Frog	Habitats may be altered by changes in hydrologic regime. Breeding sites may be destroyed or created. Individuals may be destroyed by development or production activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Columbia Spotted Frog	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Wood Frog	Not known to occur in project area.	No effect	No effect	No effect	No effect
Reptiles					
Milk Snake	Habitats may be altered, lost, or fragmented. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Fish					
Sturgeon Chub	Habitats may be altered by changes in hydrologic regime. Individuals and populations may be affected by changes in water quality and quantity.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Yellowstone Cutthroat Trout	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect

Notes:
1. Complete determination text reads as follows: "May adversely affect individuals, but not likely to result in a loss of viability on federal lands or range wide, nor result in a trend towards federal listing."
2. Complete determination text reads as follows: "May adversely affect individuals, may result in a loss of viability on federal lands or range wide, and may result in a trend towards federal listing."

The total acreage affected by CBM development would not be disturbed simultaneously, because Project development would occur over the life of the Project. Some of the disturbed acreage would be reclaimed or would be in the process of being reclaimed when new disturbances are initiated. CBM development is expected to occur at a rate faster than abandonment and reclamation of wells. In the near future, the amount of disturbed TES plant and wildlife habitats is likely to increase, although the anticipated life of CBM wells (12-20 years) indicates that reclamation would eventually overtake new well development, resulting in a net decrease in disturbed vegetation for the long-term.

Cumulative effects would also occur to TES plant and wildlife resources as a result of indirect impacts. One factor is the potential import and spread of noxious weeds around Project roads and facilities. Noxious weeds have the ability to displace native vegetation and hinder reclamation efforts. If weed mitigation and preventative procedures are applied to all construction and reclamation practices, the impact of noxious weeds on TES plants and wildlife would be minimized.

In areas reclaimed after CBM development, the reclaimed areas often differ substantially from undisturbed areas in terms of vegetation cover. Reclaimed areas may not serve ecosystem functions presently served by undisturbed vegetation communities and habitats, particularly in the short-term, when species composition, shrub cover, and other environmental factors are likely to be different. Establishment of noxious weeds and alternation of vegetation along drainages and reclaimed areas has the potential to alter TES plant and wildlife habitat composition and distribution. As a result, shifts in habitat composition or distribution may affect TES plant and wildlife species within the Project Area.

Cultural Resources

The goal of the consideration of historic properties under Section 106 of the National Historic Preservation Act of 1966 as amended (P.L. 89-665; P.L. 95515; P.L. 102-575; 80 Stat. 915; 16 USC 470), its implementing regulations, including but not limited to 36 CFR §800, 36 CFR §61, and Executive Order 11593, the National Environmental Policy Act of 1969 (P.L. 91-190; 83 Stat. 852; 42 U.S.C. 1500-17.7; 42 U.S.C. 4321-61) and its implementing regulations including 40 CFR §1500-1508, is the preservation of the cultural values embodied in those historic properties. The BLM national cultural resource management objectives to meet the requirements of the latter statutory authorities and additional related authorities listed in BLM Manual M-8100.03 are:

A. Respond in a legally and professionally adequate manner to (1) the statutory authorities concerning historic preservation and cultural resource protection, and (2) the principles of multiple use.

B. Recognize the potential public and scientific uses of, and the values attributed to, cultural resources on the public lands, and manage the lands and cultural resources so that these uses and values are not diminished, but rather are maintained and enhanced.

C. Contribute to land use planning and the multiple use management of the public lands in ways that make optimum use of the thousands of years of land

use history inherent in cultural resource information, and that safeguard opportunities for attaining appropriate uses of cultural resources.

D. Protect and preserve in place representative examples of the full array of cultural resources on public lands for the benefit of scientific and public use by present and future generations.

E. Ensure that proposed land uses, initiated or authorized by BLM, avoid inadvertent damage to Federal and non-Federal cultural resources.

The operational objectives to achieve this goal are:

1. Identification of all historic properties within the area of potential effect of proposed actions that are part of or associated with the federal undertaking;
2. Evaluation of the cultural values of those historic properties within appropriate historic contexts; and
3. Avoidance or minimization of adverse effects to those cultural values.

The cultural resources management objective of the BLM Buffalo Field Office, including stewardship considerations in addition to Section 106 and NEPA compliance is to "Protect, preserve, interpret, and manage significant cultural resources for their informational, educational, scientific, and recreational values" (BLM 2001:4).

These objectives are achieved through:

1. Inventory;
2. Evaluation;
3. Native American Consultation;
4. Management Options; and
5. Monitoring

Cultural resource sites are defined as discrete locations of past human activity, which can include artifacts, structures, works of art, landscape modifications, and natural features or resources important to history or cultural tradition. These sites can include extensive cultural landscapes (e.g., farm or ranch landscapes), linear landscapes (e.g., historic trails with associated towns, forts, and way stations), or railroad landscapes and traditional use areas. In this document, significant sites are defined as those sites that are listed on, determined eligible for, or recommended eligible for the National Register of Historic Places under the Criteria for Evaluation (36 CFR § 60.4), and sites that have not been evaluated.

Federal regulations require cultural resource inventory, recordation, and evaluation of resources in the area of potential effect as part of the approval process. All areas of proposed ground disturbing activity would be inventoried for cultural resources. Any discovered resources would be documented and evaluated for eligibility for the NRHP. With proper planning, effects to eligible properties can be avoided. Indirect effects from changes to soil stability or drainage patterns cannot always be anticipated. Indirect effects can be minimized by soil stabiliza-

tion, fencing, or protective barriers to prevent inadvertent traffic in sensitive areas. Direct effects when eligible sites cannot be avoided would be subject to mitigation procedures. Adverse effects can be mitigated by implementation of approved data recovery treatment plans. There are a large number of unevaluated sites. These sites can be avoided or additional studies can be implemented to evaluate them. In addition, specific procedures would be established for the treatment of unanticipated discoveries and human remains that were not identified by surface investigation.

Adverse effects to cultural resources can result from the construction and operation of well pads, access roads, pipelines, power lines, and compressor stations and vehicular travel. Effects to sites can be direct as a result of construction or other earth disturbing activities, or can be indirect as a function of such things as increased erosion, easier access, vibration from traffic or machinery, or alteration of the setting. Adverse affects to cultural properties may include, alteration of visual, atmospheric, and auditory aspects of site setting, or site destruction by placement of facilities and infrastructure. Indirect effects can be particularly important in the consideration of sites that are important for their location, setting, and feeling, such as emigrant trails or locations of historic battles. Cultural sites are a nonrenewable resource and, if disturbed, lose potential information, integrity, and heritage value. Avoidance of eligible sites is the preferred mitigation. Although careful project planning can help alleviate inadvertent or unintentional effects to eligible sites, such effects can still occur. Data recovery plans can be undertaken in cases where eligible sites cannot be avoided or are unintentionally affected.

Native American Consultation

Effects to traditional cultural properties, localities of traditional concern, and sacred sites must be considered. Federal regulations require consultation with recognized Native American tribes. These include, but are not limited to:

National **H**istoric **P**reservation **A**ct of 1966, as amended (P.L. 89-665; P.L. 95-515; P.L. 102-575; 80 Stat. 915; 16 U.S.C. 470-470t; 36 CFR §60; 36 CFR §65; 36 CFR §800; 36 CFR §801; 36 CFR §61; Executive Order 11593). This requires federal agencies to consult with Indian tribes regarding federal undertakings in order to identify properties with tribal religious or cultural significance that may be eligible for the National Register of Historic Places (Traditional Cultural Places), and to determine ways to avoid or minimize effects to those properties.

National **E**nvironmental **P**olicy **A**ct of 1969 (P.L. 91-190; 83 Stat. 852; 40 U.S.C. 1500-17.7; 42 U.S.C. 4321-61; 43 CFR 1500-1508). This requires federal agencies to consult with Native American tribes regarding land use plans.

Federal **L**and **P**olicy and **M**anagement **A**ct of 1976 (PL 94-579; 90 Stat. 2743; 43 U.S.C. 1701). This provides Native American tribes and groups the opportunity to express their views and identify places of concern.

American Indian Religious Freedom Act of 1978 (P.L. 95-431; 92 Stat. 469; 42 USC 1996 and 1996a; 43 CFR §7; Executive Order 13007). This requires federal land managing agencies to identify, through consultation, the concerns of traditional Native American religious practitioners, and to accommodate access to and ceremonial use of sacred sites.

Archaeological Resources Protection Act of 1979 (P.L. 96-95; 93 Stat. 721; 16 U.S.C 470aa-470mm; P.L. 100-555; P.L. 100-588). This requires consideration of Native American concerns and requires that federal land managing agencies notify appropriate tribes before approving permits for excavation of archaeological resources if the location may have cultural or religious importance to the tribes.

Native American Graves Protection and Repatriation Act of 1990 (P.L. 101-601; 104 Stat. 3048; 25 U.S.C. 3001; 43 CFR §10). Requires federal agencies to consult with appropriate tribes before the authorization of excavation or removal of Native American human remains and funerary objects with the purpose of determining how the tribes would like the agency to treat these remains.

In carrying out its mandated responsibilities, the Bureau of Land Management is obligated to ensure that the concerns that Native Americans have about federal land use plans are adequately addressed. The Bureau of Land Management must foster and maintain credible government-to-government relationships with Native American tribes.

Letters were sent to 26 tribes and various bands regarding the Powder River Basin Oil and Gas Environmental Impact Statement. Of the 26 tribes asked to participate, the Kiowa Tribe, Apache Tribe, Comanche Tribe, Teton Lakota Tribe, the Oglala Lakota Tribe, and bands of the Minneconjou, Siha Sapa, Oohenumpa, and Itazipco Lakota have expressed concerns and have asked to meet with BLM staff. These Native American groups have expressed concern over the handling of inadvertent discoveries of human remains, have asked for the opportunity to visit project areas to identify and interpret traditional cultural places, and have requested tribal monitoring of sensitive locations including archaeological sites. A meeting hosted by the Cheyenne River Sioux and attended by members of the Cheyenne River Sioux Tribe and Oglala Lakota Tribe was held in South Dakota in April 2001.

Treatments

The BLM, FS, and the State Historic Preservation Officer (SHPO) will develop a project treatment plan (outline in Appendix I). This plan would provide direction and decisions ahead of time so that actions in the field can be carried out much quicker, especially when unexpected discoveries are made. Mitigation of adverse impacts may include, site avoidance through project relocation or redesign, visual resource management including adjustment of the color of facilities, landform screening, detailed mapping and recordation, historic documentation, or data recovery.

Many areas of federal minerals in the Project Area are privately owned surface. The surface owners must be kept informed of activities that are planned on their property, including the identification and treatment of historic and prehistoric resources. They must also understand, or be reassured that resources on their property belong to them, and that they will have the option of taking possession of any cultural materials recovered on their land after the completion of appropriate documentation and analysis.

The following section briefly outlines several types of situations that may arise and potential options for dealing with those situations. These options will be discussed in more detail in the treatment plan.

Situation 1 — Unevaluated Sites:

Roughly 35 percent of the known sites in the Project Area are unevaluated. The reason that a particular site is unevaluated may include:

- The site was recorded formally or informally outside the Section 106 or NEPA processes and evaluation was not required;
- Site recording was incomplete or inadequate;
- Documentation of the historic context of the site was not pursued and information is inadequate for evaluation;
- The site is largely obscured (buried by sediment or covered by later construction episodes) and elements of the site must be uncovered to provide information for evaluation; or
- Comparative information on similar or related sites is insufficient or inadequately compiled.

If a site will be impacted by a proposed federal action it must be evaluated to determine whether it is a historic property. Depending on why the site is unevaluated it may require:

- A revisit and rerecording by current standards;
- Comparative or technical analysis of artifacts, materials, photographs, or information already gathered from the site;
- A search of public, historical or archival records to establish context and associations;
- Test excavation or partial removal of overlying fabric and structures to establish the nature and integrity of the site;
- A search of archival maps, photographs, or records to clarify earlier identity, appearance, location, or extent of a feature, building or structure; or
- Compilation of comparative data on similar or related sites.

If the effort necessary to adequately evaluate a site is excessive in comparison with the scale of the proposed action, it may be prudent to modify the proposed action to avoid the site as if it were eligible. However, it will still be necessary to verify the extent of the site and its contributing elements. If the site is unevaluated it can be difficult to adequately plan for avoidance and protection, because

part of the process of evaluation is identifying the contributing elements or characteristics of the site that need to be protected.

Situation 2 — Resources that are Eligible for their Potential to Yield Important Information

Eligibility

Historic or prehistoric artifact scatters, artifacts with surface features, or buried levels that are eligible primarily for the information they may yield (Criterion d).

Impacts

- Mechanical disturbance by earth moving activities, surface traffic, erosion, or destabilization resulting in: loss of artifacts or features; loss of the context, patterning, or internal association of artifacts and features; or loss of specialized evidence (e.g., chemical, pedological, chronometric, geomorphic) integral to the information potential of the property.
- Deterioration through neglect.
- Intentional or inadvertent displacement, mixing, or removal of site elements.

Management

- Avoidance and protection during development by stipulation of limited activity, fencing or protective barricades, and monitoring – either the entire property or contributing areas within the property.
- Prevention of erosion, sedimentation, or indirect displacement by sediment stabilization, silt fences, or other appropriate measures – both development and post-development.
- Permanent fencing after development to exclude casual traffic and grazing disturbance.
- If avoidance and protection is not feasible, or site is inadvertently damaged, approved data recovery of elements of the site that make it eligible and are threatened.

Situation 3 — Resources Eligible for their Associations

Eligibility

Properties or extensive landscapes eligible for association with an event or pattern of events important in prehistory or history or the significant contributions of a person or being important in history or tradition that is integrally associated with the location, setting and feeling, with or without artifacts, features, structures, or buildings (Criteria a and b).

Impacts

- Mechanical, visual, or auditory disturbance to the location and setting that impairs the essential character of the property that conveys the important event, pattern of events, or setting in which an important person or being developed or delivered an important contribution to history or tradition.
- Indirect or delayed disturbance by destabilization of the landscape or introduction of aggressive plants or animals out of character with the historic setting.

Management

- Avoidance and protection during development and operation of the essential character of the location and setting of the property by limitation of extent and duration of activities, fencing or protective barricades, and monitoring of the immediate property and essential elements of its location and setting including any appropriate buffer.
- Stipulations on development and operation of facilities and access to facilities so that intrusion on the essential character of the property is minimized – including minimum proximity for development and traffic, restriction of noise, restriction of activities within view of the property, or use of construction materials, styles, and colors that are in character with the setting.
- Protective measures and monitoring to prevent significant changes in vegetation, hydrology, or soil stability.
- Unavoidable impact might be mitigated by an approved plan of recordation, or recordation and restoration of the essential character and setting of the property.

Situation 4 — Resources Eligible for their Design, Materials, Workmanship or Artistic Value

Eligibility

- Properties eligible as non-portable art, architecture, or designed structures (Criterion c).
- In many cases the location, setting and feeling of these objects, buildings or structures may also be essential elements of their significance.

Impacts

- Direct mechanical damage to the essential character of the object, building or structure.
- Indirect damage or deterioration to essential design, materials, or workmanship by destabilization of underlying materials, structural vibration, dust, or damaging fumes. These might include erosion, acceleration of structural deterioration, deterioration of the underlying substrate of rock art, deterioration or corrosion of pigments or surface materials, or deposition of intrusive sediments or materials.

- Mechanical, visual, or auditory disturbance to the location and setting that impairs the essential character of the property.

Management

- Avoidance and protection during development and operation of the essential character of the object, building or structure, and of the location and setting of the property by limitation of extent and duration of activities, fencing or protective barricades, and monitoring of the immediate property and essential elements of its location and setting including any appropriate buffer.
- Stipulations on proximity, extent, and duration of traffic and activities during development and operation in order to control vibrations, dust, exhaust, and fumes that might damage or disturb the essential character of the property.
- Periodic monitoring of compliance with stipulations and the effectiveness of those stipulations.
- Stabilization of structure or underlying materials.
- Control measures to minimize dust and fumes.
- Protective materials or barriers to control the movement of intrusive or damaging materials.
- Unavoidable impact might be mitigated by detailed recordation; relocation of the object, building or structure if its location and setting are not primary essential elements of its significance; or repair and restoration.

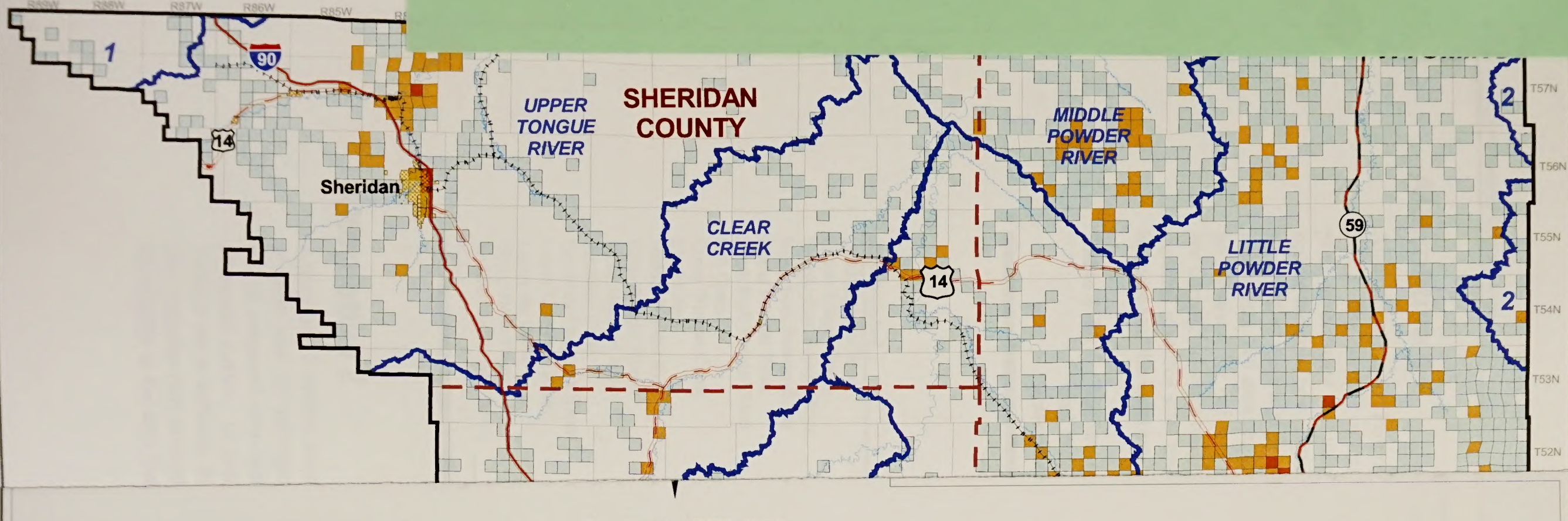
Project Alternatives

The Project Area has been divided into 18 sub-watersheds for the purpose of analysis. The total square miles, square miles surveyed, percent surveyed, and average sites per square mile by watershed are shown in Table 4–95. The amount of land involved varies greatly by watershed with the largest amount of acreage in the Upper Powder River watershed and the smallest in the North Fork Powder River. As expected, the surveyed areas and percent of area surveyed also varied greatly. Figure 4–43 shows sections in the Project Area that have had intensive surveys and the relative density of sites recorded. The average percent of area surveyed for the total Project Area is 10.2 percent with a high of 40.6 and a low of 0.7 percent. The number of sites per square mile for the total Project Area is 6.1 with the largest number of sites per square mile found in the Clear Creek sub-watershed and the smallest in the Upper Belle Fourche River sub-watershed. The Clear Creek sub-watershed is a diverse area that is likely to have a high site density. However, in this table, the site density is also inflated by thematic surveys that reported sites, but have no associated survey acreage. The total number of sites recorded in all the watersheds appears low, but is likely a result of the amount of surveyed acreage being low rather than indicating a low site density. The most common sites in the Project Area are prehistoric artifact scatters and rural historic sites.

Table 4–95 Previously Surveyed Area and Average Density of Known Cultural Resource Sites per Square Mile by Sub-watershed

Sub-watershed	Total Square Miles	Square Miles Surveyed	Percentage Surveyed	Sites per Square Mile
Little Bighorn River	77.5	0.6	0.7	13.3
Upper Tongue River	1,156.1	33.7	2.9	13.3
Middle Fork Powder River	725.7	23.8	3.3	22.2
North Fork Powder River	32.3	0.4	1.3	15
Upper Powder River	2,505.5	229.4	9.2	5.0
South Fork Powder River	178.7	5.3	3.0	7.4
Salt Creek	238.1	11.3	4.7	7.9
Crazy Woman Creek	856.7	7.9	0.9	21.3
Clear Creek	855.4	6.7	0.8	45.2
Middle Powder River	350.4	31.9	9.1	5.2
Little Powder River	1,352.3	158.6	11.7	4.6
Little Missouri River	60.2	2.7	4.5	10.7
Antelope Creek	1,031.7	206.4	20.0	4.7
Dry Fork Cheyenne River	483.3	64.0	13.2	8.9
Upper Cheyenne River	323.1	131.2	40.6	5.2
Lightning Creek	481.8	62.2	12.9	4.5
Upper Belle Fourche River	1,320.1	245.3	18.6	4.3
Middle North Platte River	332.2	41.0	12.4	7.7
Total	12,361.1	1,262.4	10.2	
Average				6.1

For planning purposes, it is assumed that the areas that have been inventoried for cultural resources in each sub-watershed are representative of the range of settings in the respective sub-watersheds. It is further assumed that cultural resource sites are randomly distributed across the landscape. Given the total number of previously recorded sites per square mile for each watershed, the number of sites expected in the remaining unsurveyed areas can be estimated. Figure 4–43 shows the estimate of square miles of total disturbance as a result of the Proposed Action and each Alternative and the number of cultural resource sites that may be affected by the proposed disturbance in each sub-watershed for the four alternatives.



Scale 1 : 775,000

5 0 5 10 15 20 25 30 35 Miles

10 0 10 20 30 40 Kilometers

Sub-Watersheds

1--Little Bighorn River

2--Little Missouri River

3--North Fork Powder River

4--Salt Creek



POWDER RIVER BASIN OIL & GAS EIS	
FIGURE 4-43 ***Distribution of Intensive Surveys and the Relative Site Density of Cultural Sites Recorded***	
ANALYSIS AREA: Campbell, Converse, Johnson & Sheridan Counties, Wyoming	
DATE: 12/26/01	ArcView File: C:\1011_v1\data\maps.apr Layout--Cultural
	DRAWN BY: MSH

Cultural Resource Data Provided by the Wyoming Cultural Records Office; Laramie, Wyoming.

Transverse Mercator Projection
1927 North American Datum
Zone 13

Alternative 1

Alternative 1 is the Proposed Action. The total square miles of potential impact is 329.3. The number of sites per square mile from Table 4–96 is used as a multiplier to estimate the number of sites in the area of potential effect given the square miles of new disturbance. The potential number of sites affected by watershed varies from a high of 1,200 to a low of zero where there is no proposed development. All areas of ground disturbance associated with federal actions would be surveyed for cultural resources during the APD process. Until those surveys are completed, only rough estimates can be made of the actual number of eligible cultural resource sites that would be affected by the proposed oil and gas development and the nature of those effects.

Table 4–96 Estimated Square Miles of Total CBM Surface Disturbance and Potentially Affected Cultural Resource Sites by Sub-watershed and Alternative

	Alternative 1		Alternative 2A		Alternative 2B		Alternative 3	
Sub-watershed	Square miles	Sites	Square Miles	Sites	Square Miles	Sites	Square miles	Sites
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	17.6	236	18.9	253	17.6	236	14.5	194
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0
Upper Powder River	109.7	549	128.9	645	123.1	616	30.8	154
South Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	1.8	14	1.9	15	1.9	15	0.5	4
Crazy Woman Creek	22.6	479	26.4	565	25.0	535	7.9	169
Clear Creek	27.3	1,234	29.5	1,333	27.7	1,252	18.3	827
Middle Powder River	6.3	32	7.1	37	6.7	35	1.5	8
Little Powder River	24.0	110	25.7	118	24.6	113	12.4	57
Little Missouri River	0	0	0	0	0	0	0	0
Antelope Creek	70.4	401	70.9	404	70.6	402	25.9	148
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Upper Cheyenne River	5.2	27	5.4	28	5.2	27	2.4	12
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche River	48.0	206	48.0	206	47.4	204	28.5	123
Middle North Platte River	0	0	0	0	0	0	0	0
Total	332.9	3,288	362.7	3,604	349.8	3,435	142.7	1,696

Alternative 2

Alternative 2 differs from the Proposed Action in the methods of boosting compression and the strategies for produced water management. Although the number of proposed new wells to be developed in Alternative 2 is the same as the Proposed Action, the area of potential disturbance presented for Alternative 2 in Table 4–96 is different than that presented for the Proposed Action. Alternative 2 also includes two methods for handling produced water (2A and 2B), which differ slightly in the area that would be disturbed.

The total square miles of potential impact for Alternative 2A is 358.5. The number of sites per square mile from Table 4–95 is used as a multiplier to estimate the number of sites in the area of potential effect given the square miles of new disturbance. The potential number of sites affected by watershed varies from a high of 1306 to a low of zero where there is no proposed development. Alternative 2B would result in less total surface disturbance (346.4 square miles) and slightly fewer cultural resource sites affected. All areas of ground disturbance associated with federal actions would be surveyed for cultural resources during the APD process. Until those surveys are completed, only rough estimates can be made of the actual number of eligible cultural resource sites that would be affected by the proposed oil and gas development.

Alternative 3

This alternative would result in no new federal wells. There would still be effects from development, drilling, and operations on private or state land. Some of the roads and water handling facilities would be located on federal lands. Federal agencies would allow these effects. Consequently, a small amount of federal land would be affected by private development in Alternative 3. The total square miles of potential effect for Alternative 3 is 141.1. The number of sites per square mile from Table 4–95 is used as a multiplier to estimate the number of sites in the area of potential effect given the square miles of new disturbance. The potential number of sites affected by watershed varies from a high of 818 to a low of zero where there is no proposed development. All areas of ground disturbance associated with federal actions would be surveyed for cultural resources during the APD process. Until those surveys are completed, only rough estimates can be made of the actual number of eligible cultural resource sites that would be affected by the proposed oil and gas development.

Management Options

Because of the requirements for compliance with federal regulations including, but not limited to Section 106 of the National Historic Preservation Act, the National Environmental Policy Act, and the Archeological Resources Protection Act, all areas on Federal lands and mineral proposed for disturbance will be inventoried for cultural resources. Procedures and standards for identifying, evaluating, and protecting cultural resources under federal jurisdiction would be spelled out in the treatment plan. Equivalent regulatory mandates are not in place for private or State of Wyoming lands. However, if a project involves a Federal permit or authorization, Federal historic preservation requirements will apply.

It is evident that all of the alternatives will result in adverse effects to large numbers of historic properties. As development progresses the opportunities for avoiding direct or indirect effects to historic properties will diminish. As more wells are developed it will become increasingly difficult to avoid visual and auditory impacts to cultural landscapes. Because of long-term planning and management considerations, cultural resource inventories should target entire plans of development (PODs) rather than piecemeal actions.

The following types of management situations will be encountered:

1. The resource is not a historic property, no further work is required;
2. The historic property is within an area of proposed disturbance, but the proposed action can be altered within areas of existing inventory to avoid direct adverse effects and protect the property from indirect adverse effects;
3. The historic property is within an area of proposed disturbance but the proposed action can be altered, relocated, or constrained within areas of existing inventory so that only non-contributing portions of the historic property are affected and contributing portions can be protected from adverse impact;
4. The historic property is not immediately within the area of proposed impact, but its location and setting are intrinsic to its eligibility, and the proposed action can be altered, relocated, or constrained in such a way that its intrusion upon the viewshed and adverse effect contributing aspects of the setting can be minimized;
5. The historic property is within an area of proposed impact but is a small property eligible under Criteria c or d and the property itself, its significant attributes, or its important data are not intrinsically tied to their location or setting and can be moved, collected, documented, or studied at minimal cost; or
6. The historic property and feasible design of the proposed action are such that avoidance and protection of the property is not a viable alternative. In such a case the cultural resource professional will propose a prudent and feasible recordation or data recovery plan to submit to BLM for review.
7. The historic property was not identified or predicted by the cultural resource inventory and was encountered during development or operation of the facilities.

The treatment plan would discuss management strategies that can be applied to the latter situations to expedite the management process. It also would specify monitoring strategies that will assess the effectiveness of management strategies in achieving preservation objectives. If management activities are not achieving their objectives, the strategies and stipulations would be modified to improve their effectiveness.

Land Use and Transportation

Land Use

This section discusses the potential effects to land ownership, land uses, and land management plans in the Project Area.

Land Status/Ownership

Surface or mineral ownership would not be expected to change by implementation of any of the alternatives. No direct or indirect effects to existing surface

land ownership or mineral ownership would occur under implementation of any of the alternatives.

Surface use and rights-of-way approvals would be obtained from appropriate federal, state, and local agencies. Access easements would be negotiated with landowners or secured through the permitting processes of the federal, state, or local jurisdictional agencies. For Alternative 1 and Alternative 2, most of the proposed wells and ancillary facilities would be located on lands for which the federal government owns the CBM mineral estate. However, not all of the surface ownership may be federally owned.

Land Use

This section discusses the short-term and long-term direct and indirect adverse effects to existing land uses that are anticipated to occur from Project implementation.

Direct and Indirect Effects

Rangeland/grazing is the primary land use that would be affected by any of the alternatives for both public and private lands in the Project Area. Direct effects to land uses result from the removal or loss of existing land uses due to direct disturbances for the Project-related facilities or activities, and occur at the same time and place as the project-related action. Indirect effects to land uses are reasonable foreseeable results of the Project-related activities that occur at a later time, or are removed in distance from the project-related action. For example, project-related activities may generate noise, dust, traffic, visual intrusion of project-related facilities or activities, and/or add new access roads into limited use areas, indirectly affecting land uses for nearby properties and/or in the regional area. Indirect effects result if the project-related activities are incompatible with the land uses adjacent to the project-related disturbance areas, and may potentially change regional land use development patterns. CBM facilities are generally considered to be incompatible with residential land uses. The compatibility effects to residential areas from CBM facilities vary based on distance, topography, vegetation, and type of facilities.

Both short-term and long-term direct adverse effects to land uses are anticipated to occur from implementation of the any of the alternatives, as a result of the surface disturbances related to construction and operation of the proposed facilities.

Short-term direct effects to rangeland/grazing and other land uses would primarily occur during the construction and installation phase for any of the alternatives. Long-term direct effects would result from displacement of existing land uses for the life of the Project facilities for implementation of any of the alternatives. After decommissioning, reclamation, and final closure of the proposed facilities, the pre-existing land uses would be re-established.

Long-term indirect adverse effects would occur to the land uses on properties adjacent to the Project-related facilities from implementation of any of the alternatives due to the generation of dust and noise, visual and aesthetic effects of the project-related facilities and activities, increased traffic levels from project-

related vehicles, and increased public access opportunities as a result of the development of new and upgraded access roads for the life of the Project.

Short-term indirect adverse effects would also occur to the land uses on properties adjacent to the Project-related facilities due to the physical intrusion of the construction crew and equipment, and the temporary obstruction or delay of traffic at road crossings during the construction and installation phase of any of the alternatives.

Alternative 1

Effects to land uses are addressed for the three primary phases of the Proposed Action: drilling and construction of facilities (short-term disturbances), production and maintenance (long-term disturbances), and decommissioning/reclamation. The overall life of the Project, including drilling, production, and reclamation is expected to be 20 years. The productive life of a single well is expected to be seven years. Within two or three years following the end of production, final reclamation of the wells would occur. After decommissioning, reclamation, and final closure of project-related facilities, the pre-existing land uses would be reestablished.

The land use disturbances associated with the Proposed Action include two primary components. The first is the CBM wells and their ancillary facilities. The second component is the non-CBM wells and their ancillary facilities.

Under the Proposed Action, wells and ancillary facilities would be installed and operated within 10 of the 18 sub-watersheds that comprise the Project Area. Most of the new wells (63 percent) and facilities would be constructed in two sub-watersheds: the Upper Powder River and Upper Belle Fourche River sub-watersheds. Other sub-watersheds with relatively high numbers of wells and facilities include Clear Creek, Crazy Woman Creek, Upper Tongue River, and Little Powder River.

Rangeland/grazing is the predominant land use that would be displaced by the project-related facilities for both the short term and long term. Short-term direct effects to existing land uses in the Project Area would result from the clearing of or damage to vegetation and disturbance of soils for the construction and installation of the proposed facilities associated with the Proposed Action. Long-term direct effects would result from displacement of the existing land uses for the production and maintenance activities that would occur for the life of the Project.

For the CBM wells, implementation of this alternative would cause short-term disturbance of as many as 211,992 acres. The short-term disturbance associated with Alternative 1 would involve about 3 percent of the almost 8 million-acre Project Area. Under the Proposed Action, surface disturbances and effects to existing land uses would occur during drilling and construction of the proposed facilities, including well pads, CMFs, roads, pipelines, power lines, compressor stations, and impoundments. Most of the short-term disturbance would be associated with the construction of the pipelines, roads, and water-handling facilities. Compressor stations would account for a small portion of the overall disturbance.

After installation of the proposed facilities, much of the disturbed land would reclaimed, revegetated, and returned to pre-existing land uses. Following reclamation of pipelines and partial reclamation of well pads and compressor stations, long-term disturbance associated with the new CBM wells would encompass about 108,799 acres. The acreage for long-term disturbance is a 45 percent reduction from the short-term disturbance. The roads and water handling facilities would comprise most of the long-term disturbance.

Under the Proposed Action, approximately 6,657 and 10,619 miles of new improved and two-track roads would be constructed, respectively. In the short-term, construction of improved roads would disturb approximately 12,965 acres, and construction of two-track roads would disturb 51,486 acres.

Of the total disturbance, short-term and long-term disturbances associated with the well pads for the Proposed Action are 10, 474 acres and 3,938 acres, respectively. The disturbances associated with the various pipelines for the Proposed Action would be short-term. Following reclamation of the pipelines, no long-term disturbance is anticipated. Reclamation would begin immediately after installation of underground pipelines.

A large portion of the disturbances associated with the Proposed Action are associated with the large upland reservoirs that would be constructed to contain the produced water over the life of the Project. Approximately 32,685 acres of total surface area would be disturbed both short-term and long-term for the water handling facilities for the Proposed Action. Each reservoir would have a total disturbance area of approximately 140 acres. Most of this disturbance would occur within the Upper Powder River and Upper Belle Fourche River sub-watersheds.

In addition to the disturbances associated with the CBM wells, about 3,200 non-CBM wells would also be completed over a 10-year period as part of the Proposed Action. Of these wells, 3,000 would be drilled within the Buffalo Field Office Area, and 200 wells to be located within the Casper Field Office Area. The projected maximum disturbance due to non-CBM wells is 5.5 acres and 4.5 acres per well for short-term and long-term disturbances, respectively. Short-term disturbance associated with the construction of non-CBM wells would affect almost 17,600 acres of the Project Area. Most of this disturbance would occur in three watersheds: Little Powder River, Upper Belle Fourche River, and Upper Powder River. Once the non-CBM wells are operational and partial reclamation has occurred, the long-term disturbance would be reduced to approximately 82 percent of the original disturbance, or approximately 14,402 acres.

Long-term indirect adverse effects to the land uses on properties adjacent to the Project-related facilities would occur from implementation of the Proposed Action due to the generation of dust and noise, visual and aesthetic effects of the project-related facilities and activities, increased traffic levels from project-related vehicles, and increased public access opportunities as a result of the development of new and upgraded access roads for the life of the Project. Short-term indirect adverse effects to the land uses on properties adjacent to the Project-related facilities would also occur due to the physical intrusion of the construction crew and equipment, and the temporary obstruction or delay of traffic at

road crossings during the construction and installation phase of the Proposed Action.

Alternatives 2A and 2B

With the exception of the overall methods for handling the disposal of produced water, the land use effects associated with implementation of Alternative 2 are similar to those for the Proposed Action. Compared to Alternative 1, the changes in water handling methods included as part of this alternative slightly lower the number of acres that would be disturbed for both the short-term and long-term if this alternative is implemented.

For Alternative 2A, short-term disturbance would be approximately 248,485 acres of total surface area. Long-term disturbance associated with Alternative 2A would be 142,095 acres. Much of this long-term disturbance is associated with approximately 51,579 acres of surface area that would be disturbed for the water handling facilities to contain the produced water from the proposed CBM wells.

For Alternative 2B, short-term disturbance would be approximately 240,459 acres of total surface area. Long-term disturbance would be 134,069 acres, of which 43,553 acres would be associated with the water handling facilities.

For both Alternative 2A and Alternative 2B, rangeland/grazing is the predominant existing land use that would be displaced by the project-related facilities for both the short-term and long-term effects.

Alternative 3

Under this alternative, development of non-federal CBM wells would continue to occur on non-federal lands within the Project Area. The agencies assumed development of private and state minerals would occur along the same overall schedule as for Alternative 1. The Companies would drill approximately 15,458 new CBM wells between 2002 and 2011. These wells would be in addition to the 12,077 CBM wells already permitted or drilled on federal, state, and private lands within the Project Area. A total of 27,535 CBM wells would be developed by 2011 under this alternative.

As described under Alternative 1 and Alternative 2, some of the new CBM wells would be drilled from the same well pads; therefore, the number of pads constructed would be less than the number of wells drilled. A total of 10,534 new well pads would be constructed between 2002 and 2011. Including the 9,592 pads constructed or permitted prior to 2002, implementation of Alternative 3 would result in a total of 20,126 well pads by 2011.

Because fewer new wells would be drilled and fewer pads constructed, the number of facilities constructed would be smaller than under the Proposed Action. The overall short-term and long-term disturbances associated with this alternative would be less than that which would occur with implementation of Alternative 1 or Alternative 2.

Short-term direct adverse effects to land uses would result from the clearing of or damage to vegetation and disturbance of soils for the drilling and construction of facilities associated with any of the alternatives. For Alternative 3, short-term direct effects associated with the CBM wells would displace approximately 90,807 acres from the existing land uses, primarily rangeland/grazing. In addition, almost 17,599 surface acres would be disturbed by construction of non-CBM wells. Most of this disturbance would occur in three sub-watersheds. They are the Little Powder River, Upper Belle Fourche River, and Upper Powder River.

Long-term direct effects to land uses would result from the production and maintenance activities for the life of the Project. Once the CBM wells are operational and partial reclamation has occurred, long-term direct effects associated with the CBM wells would displace approximately 45,057 acres from the existing land uses, primarily rangeland/grazing. Approximately 14,384 acres of the total long-term disturbance would be displaced for the water handling facilities to contain the produced water from the proposed CBM wells. The long-term disturbance from the non-CBM wells is estimated to be an additional 6,339 acres.

Under Alternative 3, the existing land uses in the Project Area would continue to receive long-term indirect adverse effects would occur due to the generation of dust and noise, visual and aesthetic effects of the project-related facilities and activities, increased traffic levels from project-related vehicles, and increased public access opportunities as a result of the development of new and upgraded access roads for the life of the Project. Short-term indirect adverse effects to the land uses on properties adjacent to the Project-related facilities would also occur due to the physical intrusion of the construction crew and equipment, and the temporary obstruction or delay of traffic at road crossings during the construction and installation phase of any of the alternatives.

Consistency with Land Use Plans

Implementation of either Alternative 1 or Alternatives 2A and 2B would be consistent with land use plans of the State of Wyoming, the planning goals of the four counties, and planning goals of numerous incorporated areas within the Project Area. The results of the analysis of federal land use plans are presented in Chapter 5.

Although some of the proposed wells are within or near incorporated areas, primarily near the City of Gillette, zoning regulations allow oil and gas development within designated zoning districts. CBM facilities are generally considered to be incompatible with residential land uses. The degree of compatibility of CBM facilities adjacent to residential areas varies based on distance, topography, vegetation, and type of facilities.

Cumulative Land Use Effects

Under Alternative 1 or Alternatives 2A and 2B, the Companies would drill, complete, and operate an additional 39,367 new CBM wells within the Project Area by the end of 2011. Including the 12,077 CBM wells already permitted in the Project Area, Alternative 1 or Alternative 2 would have a cumulative total would of 51,444 new CBM wells, and 3,200 non-CBM wells within the Project Area by

the end of 2011. The life of the Project for either of the action alternatives would be 20 years, and project-related activities would be completed around 2021.

Under Alternative 3, the Companies would drill approximately 15,458 new non-federal CBM wells between 2002 and 2011. These wells would be in addition to the 12,077 CBM wells already permitted or drilled on federal, state, and private lands within the Project Area. A cumulative total of 27,535 CBM wells would be developed by 2011 for this alternative.

Under any of the alternatives, the existing land uses would be temporarily displaced by the Project-related facilities over the life of the Project, primarily at CMFs, compression facilities and the water handling facilities where other uses would be fenced out.

Based on a comparison of acres of the total surface area disturbed for the Project facilities associated with each alternative, both short-term and long-term direct and indirect land use effects would be substantially less for Alternative 3, than for Alternative 1 or Alternative 2. Short-term disturbance associated with the CBM wells for Alternative 1 would affect approximately 230,703 acres. For Alternative 1, Alternative 2A, and Alternative 2B, the short-term disturbance associated with the non-CBM wells is estimated to affect approximately 17,599 acres. The short-term and long-term disturbances associated with Alternative 2A are estimated to affect approximately 232,180 acres and 128,987 acres, respectively. Alternative 2B would result in disturbances of approximately 223,934 acres and 120,741 acres over the short term and long term, respectively. Under Alternative 3, short-term and long-term disturbances would affect approximately 91,275 acres and 45,525 acres, respectively.

Transportation

This section discusses the potential effects to the transportation resources within the Project Area.

Effects to transportation resources are addressed for the three primary phases for each of the alternatives: construction and installation, operation and maintenance, and decommissioning/reclamation. The productive life of a single well is expected to be approximately 7 years. Within two or three years following the end of production, final reclamation of the wells would occur. The overall life of the Project, including drilling, production, and reclamation is expected to be 20 years.

Effects on the existing transportation system and traffic levels in the affected subwatersheds would vary between the initial short-term construction and installation period (approximately one to two years for a given area), and the long-term operation and maintenance period for the life of the Project (20 years).

For any of the alternatives, prior to the construction of any new roads that are to access an existing state or county road, an access permit must be obtained from the Wyoming DOT. The application form for an access permit must include location of proposed road construction, and roadway design specifications, including type of surface material, drainage structures, roadway width, profile and grades.

Rail service and airports within the Project Areas would not be impacted by any of the alternatives. Drilling operations for any of the alternatives would comply with the Federal Airport Regulation Sub-Part 77 (FAR Part 77) requirements. Obstructions to air navigation are defined as any structure that is 200 feet in height above ground level or above the established airport elevation, whichever is higher, and within three miles of the established airport reference point. The FAA Form 7460-1 "Notice of Proposed Construction of Proposed Construction or Alternation" is required to be submitted to FAA at least 30 days before construction activities near an airport.

Assumptions of transportation-related impact analysis:

- The construction and installation phase for any of the alternatives would occur within the entire Project Area over approximately a 10-year period. Short-term and long-term increases in daily traffic would result from the proposed activities for any of the alternatives.
- Equipment needed for construction and installation of the proposed facilities for any of the alternatives would include heavy equipment (mobile drilling rig, bulldozers, graders, track hoes, trenchers, and front-end loaders), and heavy- and light-duty trucks.
- Short-term increases in daily traffic were assessed for all the alternatives based on the daily travel of the average number of estimated workers for the construction and installation phase of the proposed facilities, and would occur for approximately 10 years over the entire Project Area.
- Long-term increases in daily traffic were assessed for all alternatives based on the daily travel of the average number of estimated workers for the operation and maintenance phase of the proposed facilities, and would occur for the estimated 20-year life of the Project over the entire Project Area. For the entire Project Area, the operation and maintenance phase for any of the alternatives would occur concurrently with both the construction and installation phase, and the decommissioning/reclamation phase.
- Short-term increases in daily traffic were assessed for all the alternatives based on the daily travel of the average number of estimated workers for the decommissioning/reclamation phase of the proposed facilities, and would occur for approximately 10 years over the entire Project Area.
- Increases in average daily traffic counts would occur on the primary access roads into the Project Area, predominantly I-25, I-90, U.S. Highways 14 and 16, and State Highways 59 and 387.
- The additional traffic generated by the project-related vehicles was estimated based on the estimated average number of workers per day for Alternative 1 and for Alternative 3). The additional project-related traffic would be distributed throughout the entire Project Area.
- To compute the increases to average daily traffic count for the roads in the Project Area due to project-related vehicle trips for all of the alternatives, an average of 1.5 workers per vehicle was assumed for both the short-term construction and installation phase, and for the decommissioning/reclamation phase. One worker per vehicle was assumed for the operation and maintenance phase. Each worker was assumed to make one round trip per day.

- No new public roadways or new intersections would be built under any of the alternatives.
- A significant traffic volume impact would occur if the Project-related vehicle trips generate a 25 percent or more increase in the average daily traffic count compared to the existing (background) average daily traffic counts for the major access roads in the Project Area.
- An increase in accident rate is likely at intersections, or locations such as where a lane merges, if the increase in number of vehicles entering existing intersections is significantly higher than (10 percent of more) background conditions.

Alternative 1

Under the Proposed Action, approximately 6,657 and 10,619 miles of new improved and two-track roads would be associated with the new CBM facilities, respectively. Most of the roads to access well pads (resource roads) would be developed in two steps. Initially each road would be roughed in as a two-track road with an approximately 10 foot-wide rights-of way. Generally, the BLM requires improved graded and graveled roads with approximately 40 foot-wide rights-of way to conventional oil and gas operations. However, because the need to travel to the CBM wells is very limited, the BLM has waived the blanket requirements for road improvements to minimize surface disturbance. Road surfacing needs would be determined in consultation with the BLM or landowner based on site-specific conditions.

New access roads located on BLM or FS lands would meet BLM minimum road design and maintenance requirements, which are provided in BLM Manual Section 9113 – Roads (BLM 1985c) and the BLM Wyoming Supplement (BLM 1991). Road routes, locations, and design criteria are included in the APD and/or rights-of-way applications. The operators would provide the BLM with copies of all road maintenance agreements.

Unless work is needed to alleviate concerns about safety or access difficulties, the roads to access well pads would be maintained in a two-track status. Gravel may be applied to problem areas, such as stream drainage crossings, low water crossings, and areas of rough topography.

The counties and Companies would primarily be responsible for maintaining the Project's improved roads in the Project Area. The counties would maintain the existing county roads and any roads covered by maintenance agreements with BLM. The Companies would maintain all other project roads.

In general, the Companies would reclaim access roads required for construction but not needed for production as soon as practical. If a well is not successful and is plugged, the road would be reclaimed. However, with the surface owners' concurrence, the Companies could leave the road in place where there is value for ranching or agricultural uses. If a landowner decides to keep a road, then the landowner would accept responsibility for maintaining the road upon abandonment by the Companies.

Reclamation of access roads would be performed after production activities are completed. Access roads would be reclaimed by ripping/plowing and seeding unless the landowner and/or land manager wishes to make use of any roads and accepts responsibility through execution of a release for future road maintenance. Roads not needed for further work would be blocked, re-contoured, reclaimed, and reseeded/revegetated. Reclamation would be consistent with the requirements of the federal managers (according to Onshore Oil and Gas Order No. 1, Approval of Operations), and the State of Wyoming. On private lands, the Companies would execute release of the roads to the landowner or reclaim it according to the terms of the surface use agreements that may be in effect at that time.

All road disturbances on federal lands would be reseeded with a seed mixture approved by the Authorized Officer, as described in the APD Surface Use Program or Conditions of Approval. The seed mixture would be planted in the amounts specified in pounds of pure live seed per acre. All seed mixtures would be certified as weed free. Commercial seed would be either certified or registered seed. Seeding and/or planting would be repeated until satisfactory revegetation is accomplished.

For the Proposed Action, the average number of project-related workers per day would decrease from 1,043 workers during the initial short-term construction and installation period, to 395 workers per day during the long-term operation and maintenance period. Drilling, well installation, and completion for an individual well is anticipated to take approximately six days, requiring an average of 5 workers per day.

The average number of workers required for the decommissioning/reclamation phase for this alternative is estimated to be approximately 603 workers per day. During the decommissioning/reclamation phase, there would be short-term increases in traffic generated during the removal of equipment and reclamation at the individual well sites. Reclamation is estimated to require about three workers per day for five days per facility.

Transportation-related effects from implementation of the Proposed Action are summarized:

- The average daily traffic would increase by approximately 3,129 additional vehicle trips (based on estimated number of workers per day), distributed over the various roads within the entire Project Area for the short-term construction and installation phase of the Project.
- The average daily traffic would increase by approximately 790 additional vehicle trips (based on the estimated number of workers per day) for the long-term operation and maintenance phase of the Project, distributed over the various roads within the entire Project Area.
- The average daily traffic would increase by approximately 1,206 additional vehicle trips (based on the estimated number of workers per day) for the decommissioning/reclamation phase of Project, distributed over the various roads within the entire Project Area.
- Based on the proposed well locations, approximately 63 percent of the additional daily traffic due to project-related vehicles would occur within the

Upper Powder River and Upper Belle Fourche River sub-watersheds. Project-related traffic would be dispersed throughout these two sub-watersheds, and would result in a relatively large increase in traffic on state and local roads during the life of the Project, primarily affecting State Highways 59 and 387.

- Most of the remainder of the additional daily traffic due to project-related vehicles would occur in the Clear Creek, Crazy Woman Creek, Upper Tongue River, and Little Powder River sub-watersheds due to the relatively high numbers of proposed wells and facilities.
- The estimated increases to average daily traffic due to project-related vehicles is more than a 25 percent increase, compared to the existing average daily traffic counts for some of the roads in Project Area.
- The estimated increase in risk of traffic accidents due to additional the traffic of project-related vehicles, would be approximately the same percent increase as the percent increase in average daily traffic counts due to project-related vehicles, compared to the existing daily traffic counts for the roads in the Project Area.
- Relatively minor traffic delays, caused by short-term lane closures, would occur at some of the road crossings in the Project Area during the short-term project-related activities.

Alternatives 2A and 2B

For Alternatives 2A and 2B, the estimated employment requirements and anticipated trips per day would be approximately the same as those discussed for Alternative 1. The effects to transportation resources associated with the implementation of Alternatives 2A and 2B would be the same as those described for Alternative 1.

Alternative 3

Because fewer new wells would be drilled and fewer pads constructed, the number of average workers per day would be less than that under the Proposed Action. Assuming an average of 353 workers per day for the construction and installation phase associated with implementation of Alternative 3, the average daily traffic would increase in the short-term by approximately 1,059 additional vehicle trips (based on estimated number of workers per day), distributed over the various roads within the entire Project Area.

For Alternative 3, an estimated average number of 169 workers per day are required for the long-term operation and maintenance phase for the 20-year life of the Project throughout the entire Project Area. This results in long-term increase in the average daily traffic of approximately 507 additional vehicle trips, distributed over the various roads within the entire Project Area.

Approximately 230 additional project-related vehicle trips are estimated for the short-term decommissioning/reclamation phase of Alternative 3, distributed over the various roads within the entire Project Area.

The estimated increases to average daily traffic, due to project-related vehicles for the short-term construction and installation phase of Alternative 3, are an in-

crease of more than 25 percent, compared to the existing average daily traffic counts for some of the roads in Project Area.

Cumulative Transportation Effects

Direct adverse effects to the primary access routes within the Project Area, including State, BLM, FS, and county roads, would occur due to project-related vehicular traffic associated with the implementation of any of the alternatives. The additional traffic is expected to increase the rate of degradation of the existing roadways in the Project Area, primarily in the Upper Powder River and Upper Belle Fourche River sub-watersheds.

Visual Resources

Development of coal bed methane in the Project Area would alter the physical setting and visual quality of the landscape, and affect the landscape as experienced from sensitive viewpoints, including travel routes and popular use areas. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture, which characterize the existing landscape. The landscape provides a scenic setting for recreational and residential uses of the area.

Direct effects to visual resources occur due to the disturbance of the landscape by project activities and the addition to the landscape of proposed facilities, including the well pads, pumping units, compressors, and associated electric power lines, pipelines, and access roads. Direct effects can be short or long term.

Short-term effects result from temporary disturbances to visual resources, including construction and installation activities. Short-term effects to the visual character of the landscape can result from construction of small temporary pits on drill sites, well drilling, and construction of ancillary facilities, such as access roads, pipelines, power lines, CMFs, and compression stations.

Long-term effects result from the addition of permanent structures to the landscape and from the operation of facilities. Long-term disturbance would result from the development of wells pads, CMFs, improved and two-track access roads, power lines, and compressor stations. Effects from long-term disturbance would occur over the expected 20-year life of the Project. The largest effects would occur from the addition to the landscape of wells and the disturbances resulting from the removal of vegetation on well pad areas and access roads. Each two-track well access road would connect with local roads that provide access into the Project Area. All gathering lines, water lines, high pressure gas lines, and underground electrical cables would be located along road ROWs wherever feasible, and would likely result in visual effects that exceed those of the access roads alone.

Alternative 1

Construction Disturbance

Short-term effects during the 10-year construction period to the visual character of the landscape at each well pad would result from well pad construction, well drilling, and associated construction of ancillary facilities, such as access roads, power lines, pipelines, and compressor stations. Construction and installation of pipelines would immediately follow construction of access roads and well pads and coincide with the completion of well drilling. Each well pad access road would connect with local roads that provide access in the Project Area. All gathering lines, water lines, high-pressure gas lines and power lines would be located adjacent to road ROWs. A summary of estimated short-term disturbance from each type of facility within each sub-watershed is estimated in Chapter 2.

The short-term disturbance associated with implementation of this alternative could disturb as many as 179,307 acres or approximately 2 percent of the Project Area. Most of the disturbance would occur on federal, state, and private lands inventoried with VRM Class IV. Most of the disturbance would result from the construction of pipelines and roads. Temporary disturbances would not conflict with VRM objectives because for each well pad and associated access road and power line, construction disturbances would occur over a period of less than two years, after which they would be reclaimed back to permanent disturbances associated with operations and maintenance. VRM objectives address modifications to the landscape from long-term facilities.

Drill site preparation, drilling, and well completion activities are generally short-term effects. Drilling would occur over a 10-year period throughout the Project Area. Drilling activities associated with individual wells would be short-term, typically occurring 24 hours per day for a one to three day period for each well. Drilling activities would occur at night, so that lighting on drill rigs would be visible from residences with a direct line-of-sight to well sites. During the construction period, these activities would detract from the visual quality of the landscape and potentially conflict with residential and recreational uses, because they would be visually and audibly intrusive to residents and visitors. However, construction activities would be spread over the 10-year construction phase. The visual intrusion of these activities would be site specific and would not affect viewers outside of the viewshed of each construction site in the Project Area. The effects to the existing landscape from drilling are site specific and would occur at specific locations for no more than three days per drill site throughout the 10-year drilling period. The total disturbance associated with construction activities would not all occur at the same time within the overall ten-year construction phase. Some sites would be reclaimed back to the permanent disturbance areas before construction at other sites.

Drilling activities would be accomplished using drilling rigs, water trucks, backhoes, graders, or dozers and well servicing equipment. During a period of one to three days, these activities would detract from the visual quality of the landscape at each drill location. Once each well is completed, all disturbed areas not needed for production facilities would be restored. The mud pit would be dried and backfilled. Seeding of these areas would take place as soon as practicable.

In addition to the disturbances created by construction on the sites, there would be traffic associated with moving equipment over public highways and local roads. Trucks would be used to transport drilling components, auxiliary components, and personnel to each well site.

Construction activities would be evident to people using roads within the Project Area. Residents and visitors in the Project Area would be impacted by the sight, dust, and noise of construction activities. In addition, the transport of equipment and materials to the Project Area would be evident to other travelers on local highways that would be used to access well sites.

Permanent Disturbance

The Proposed Action would constitute a change of the visual character of the existing rural landscape that characterizes most of the Project Area. The addition of well sites and associated access roads and power lines would result in a mixed rural/industrial landscape. The components with the highest potential to adversely affect the visual character of the area are the well pad clearings, pumping units, power lines, and access roads. The operation of the proposed facilities would introduce new elements of form, line, color, and texture into the landscape, and would essentially dominate foreground views and be obvious in middle ground and background views.

Long-term effects over the life of the Project would result from the addition of the wells to the landscape and the disturbance of lands used for associated facilities, such as power lines, water handling facilities, and compressor stations. The most visible components of the proposed facilities are expected to be the clearings for well pads and access roads, wellhead facilities, CMFs, water handling facilities, and compressor stations within the Project Area. CBM development is expected to modify the visual character of the existing rural landscape in the affected sub-watersheds that previously had little or no oil and gas development. Proposed activities would not change the rural/industrial character of the landscape near Gillette and along segments of Project Area highways, which currently includes considerable modification from other oil and gas activities and from coal mining.

Most existing oil and gas development exists in the Little Powder, Upper Belle Fourche, and Upper Powder River sub-watersheds in the general vicinity of Gillette. The landscape in this portion of the Project Area is characterized by oil and gas development occurring in 80 to 160 acre well spacing patterns. Additional CBM development in these three sub-watersheds would increase the areal extent of the industrial components of the rural/industrial landscape. However, the overall landscape character in this area would remain similar to the existing landscape.

Once well productivity is established, production facilities would include a weatherproof box structure placed over the wellhead and a metal fence or rail placed around the box and electrical panel to protect them from livestock. There would be no pump jacks or other facilities at the wellheads. The facilities would be painted in non-reflective colors that harmonize with the surrounding landscape. The well pads would be 0.1 to 0.3 acres in size, depending on the number

of wells located on the pads. Production facilities would be visible primarily in the foreground distance zone of about 0.5 miles or less from any viewing area. In the foreground/middleground to background distance zones (or greater that 0.5 miles from a viewing area) the facilities would blend with the existing colors of the surrounding environment. The well pad clearings and access road disturbances would be visible in all zones due to contrasts in color and texture with the surrounding vegetation. The collocating of wells on a well pad minimizes the overall effect to the landscape by reducing the number of well pad clearings required for production facilities.

The largest effects would be to residential areas and isolated residences in the Upper Powder, Upper Belle Fourche, Clear Creek, Little Powder, Antelope, and Upper Tongue River sub-watersheds, particularly in those sub-watersheds in the general vicinity of Gillette. Several well pads with one or more wells would be adjacent to or within foreground distance zones of up to a mile from residences in some subdivisions located adjacent to Gillette municipal boundaries. Visible features would consist of well production facilities, well pad clearings, and access roads. Facilities would be most visible to travelers on affected highways during that period of time when they are within the line of sight as they travel towards the facility.

Approximately 10,619 miles of two-track roads and 6,657 miles of improved roads would be constructed to access proposed facilities from highways and local roads in the Project Area. Two-track roads would be used to access CBM wells in many cases because the need to travel to CBM wells is very limited. Two-track roads comprise a visible disturbance on the ground surface; however, as no surfacing is required, the visible disturbance from a two-track road is considerably less than the disturbance required for improved access roads. Improved roads would be constructed for some areas in rugged terrain and for non-CBM operations. Improved roads require a greater area of disturbance per mile of road and provide a greater degree of contrast between the road and the surrounding vegetation than two-track roads. Access roads would be visible primarily in the foreground zones. The visual impact of each road can be lessened by aligning the road with the contours of the topography instead of cutting across the contours to the well pad, particularly on slopes. However, this method of aligning the roads may result in a greater area of disturbance. All roads constructed for the Project would be removed and reclaimed, unless specifically requested by the landowner or county.

The gas-gathering and water-gathering pipelines would be buried adjacent to existing and new road ROWs. The combined ROW of each road and pipeline would vary according to the type of pipeline installed along the road. Installation of the pipeline would avoid trees, where practicable, and brush and woody vegetation would be left in-place and driven over so that it is potentially capable of redeveloping a vegetative canopy. Reclamation would begin immediately after burying the pipeline. There would be no long-term effects to the landscape once pipelines are installed and reclaimed.

Aboveground electric distribution lines would connect wells and compressor stations with the existing transmission and distribution system within the Project Area. Electricity would be routed to facilities along the access roads or on additional ROWs (30 feet wide) across open land. Construction of power lines would follow access road development and coincide within the completion of well drilling. Power lines typically would be installed on 35-foot poles, which would be required approximately every 300 feet. Approximately 5,311 miles of aboveground power lines would be installed in the Project Area. The pole structures would introduce straight, vertical lines and color contrasts. The effects from the introduction of these elements into the landscape can be noticeable when viewed from sensitive viewpoints when structures are visible in scenic landscapes and when structures are skylined.

Each compressor station would be lit at night with 250-watt, clear lamp lights. Each light would be mounted on a pole or building and directed downward to illuminate the facility while minimizing the amount of light projected outside the facility. This type of night lighting would minimize the night shine from each facility. However, the stations would be visible at night to residents in nearby residential areas, isolated residences, or travelers on highways and local roads.

Produced water from CBM wells would be discharged by five methods: surface discharge at outfalls, containment in large upland evaporation reservoirs, spread on the land surface at LAD sites, or injected at an injection well facility site. The proposed water handling methods would disturb a total of 32,685 acres of surface land. Nearly half of the disturbance would occur from infiltration impoundments (45 percent). Water disposal at infiltration impoundments, containment reservoirs or LADs would result in modifications to the surrounding landscape at the disposal sites. Surface discharge in some areas may cause a red surface staining from iron oxidation where water is retained at the discharge point long enough for oxidation to occur before surface discharge. The impact to the landscape would be limited in areas where these conditions would occur.

Each infiltration impoundment would consist of a shallow impoundment that would encompass an average of 6 acres, with an average dam height of 13 feet. Impoundments would be located in upland and bottomland areas. A total of 14,566 acres would be disturbed by infiltration impoundments, primarily in the Upper Powder River, Upper Cheyenne River, Crazy Woman Creek, and Upper Tongue River sub-watersheds. The majority of these areas are inventoried with VRM Class IV. The sites would have a low profile and would not be easily visible in the middleground and background zones from viewpoints at similar or lower elevations. The average 13-foot height of the dams would be the most visible feature of the impoundments, as the top of each dam would appear as a horizontal, linear form that would contrast with the natural terrain. Evaporation atomizers would be placed on towers that are likely not more than 40 feet in height, and would appear as a weak vertical contrast with the surrounding terrain. The spray from atomizers would be visible in foreground distance zones, but would be indistinct in middle ground to background zones. Infiltration impoundments would be obvious in the foreground zone as seen from nearby roads and residences. Setting the impoundments back from roads, leaving a buffer zone of topography and vegetation, would mitigate the visual intrusion

LAD sites would contain all water discharged over the life of 40 wells, affecting 1,780 acres of land surface (5.4 percent of total acres disturbed by water handling methods) in the Project Area. Each LAD site would be comprised of four 16-acre LAD areas. The LAD sites would be located in relatively flat terrain to minimize off-site drainage and earth-moving activities. The sites would have a low profile and would not be easily visible in the middleground and background zones from viewpoints at similar or lower elevations. The evaporation atomizers placed on towers would constitute a weak linear visual intrusion. LAD sites would be obvious in the foreground zone as seen from nearby roads and residences. Setting the LAD sites back from roads, leaving a buffer zone of topography and vegetation, can mitigate the visual intrusion. LAD sites would be located near containment reservoirs, which would provide temporary storage for those time periods that the LAD site is not operational. In addition, the reservoirs would store water meant for LAD applications. The water disposed of at LAD sites is of a quality not suitable for surface discharge. Land application of this water would result in modifications to the existing vegetation, providing some contrast with existing vegetation.

The proposed containment reservoirs would affect approximately 2,247 acres. The average disturbed area for each reservoir would be 100 acres. The disturbed area is comprised of the surface area of each reservoir, the dam, and diversion ditches. Reservoirs would be constructed in upland areas, away from drainages, floodplains, and gravelly terraces. These areas are generally outside of the viewsheds of most transportation routes and communities in the Project Area. In general, the upland locations of reservoirs could result in additional disturbances from earth-moving activities and extensive diversion ditches. Those LAD sites that would be located near reservoirs in upland areas would also require more earth-moving activity than those located in flatter terrain, resulting in greater disturbances to the character of the landscape.

BLM Lands

A total of 5,613 CBM wells distributed on 3,461 well pads are proposed for BLM surface ownership in the Project Area, accounting for 14.3 percent of the 39,367 new CBM wells proposed for the Project Area. The BLM has inventoried all lands within the Project Area with the VRM system. However, only lands administered by the BLM are managed with VRM objectives. Although proposed CBM wells on state, private, and Forest Service lands are not managed for BLM's VRM objectives, the inventory provides an assessment of the existing scenic quality and the ability of these lands to absorb effects to the landscape from development activities.

Table 4–97 summarizes all proposed CBM wells in the Project Area proposed for Alternative 1 by sub-watershed and VRM Class inventory. The disturbance acres for well pads include the disturbance associated with ancillary facilities connected to the pads, such as roads, pipelines, and power lines. Water handling facilities, such as LADs and containment reservoirs, may be located on BLM lands, but specific locations by VRM Class are unknown.

There are 4,530 wells and 35 compressors proposed for BLM lands managed with VRM Class IV objectives. Most of the remaining wells and compressors are located on private lands and a small number are on state and Forest System lands. Lands inventoried with VRM Class IV account for most lands within the Project Area. Most CBM wells proposed for these lands are within the Upper Powder River sub-watershed. Class IV objectives provide for major modification to the landscape and allow management activities to dominate the landscape. The construction and operation of each well and the ancillary facilities would be consistent with VRM Class IV objectives. Consequently, none of the disturbed acreage would be displaced from the existing BLM inventory of lands managed with VRM Class IV. The proposed facility developments would be consistent with management objectives.

There are 3,939 wells distributed on 417 well pads and three compressor stations proposed for BLM lands managed with VRM Class III objectives. Class III lands in the Project Area are located primarily along major transportation routes and recreation areas. Class III objectives are to provide for management activities that may contrast with the basic landscape elements, but remain subordinate to the existing landscape character. Implementation of this alternative along highways and in areas not currently developed with CBM wells would change the existing rural landscape to a rural/industrial landscape primarily because the 40- to 80-acre spacing of the wells would result in a noticeable density of industrial facilities. There is potential that Class III objectives would not be met because the facilities would not be subordinate to the existing landscape character. BLM objectives for some Class III facilities would be met if every attempt were made to minimize adverse visual effects through careful location of facilities, minimal disturbance of the site, and painting of facilities so they harmonize with the colors of the surrounding landscape.

Table 4–97 Proposed Wells and Well Pads in VRM Classes by Sub-watershed in the Powder River Basin Project Area

	Class II			Class III			Class IV			Class V			Total		
Sub-Watershed	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Total Proposed Wells	Total Proposed Pads	Long Term Pad Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	163	54	124	358	192	439	2,068	892	2,040	0	0	0	2,589	1,138	2,602
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	782	448	7,157	2,634	1,461	23,339	15,551	9,933	158,676	0	0	0	18,967	11,842	189,171
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	37	37	14.3	0	0	0	37	37	14.3
Crazy Woman Creek	0	0	0	414	397	1,437	2,506	1,500	5,429	0	0	0	2,920	1,897	6,866
Clear Creek	187	185	736	907	540	2,150	2,659	1,861	7,409	0	0	0	3,753	2,586	10,296
Middle Powder River	0	0	0	0	0	0	958	465	384.6	0	0	0	958	465	385
Little Powder River	0	0	0	25	18	84	1,810	1,077	5,000	200	170	790	2,035	1,265	5,873
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	91	83	1,342	1,553	1,368	22,117	0	0	0	1,644	1,451	23,459
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	487	487	355	46	46	34	533	533	388
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	752	644	5,084	5,046	4,005	31,617	133	134	1,058	5,931	4,783	37,759
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,132	687	8,017	5,181	3,335	33,874	32,675	21,625	23,3042	379	350	1,881	39,367	25,997	276,813

Note: Disturbance acres for well pads include the disturbance associated with ancillary facilities such as roads, compressors, and transmission lines. Totals may not match precisely with values obtained by adding unit numbers or with distributions of pads and wells presented in Chapter 2 due to rounding conventions.

There are 317 wells and two compressor stations proposed for BLM lands managed with VRM Class II objectives. None of these wells would be in the Class II lands in the western part of the Project Area at the base of the Big Horn Mountain. All 317 wells would be within the Class II areas along portions of Interstate 90 and State Highway 14.

The VRM Class II objective is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low and not attract the attention of the casual observer. Many of the CBM wells on BLM lands would be visible to travelers on Interstate 90 and State Highway 14. All of the wells proposed for these areas are within the foreground distance zone (up to three miles) of the viewshed as seen from the highways. The Proposed Action would change the existing rural landscape to a rural/industrial landscape primarily because the 40- to 80-acre spacing of the wells would result in a noticeable density of industrial facilities. The Class II objectives would be met if mitigation measures were used to maintain the existing character of the landscape, and not attract the attention of the casual observer. In order to achieve this objective, mitigation must repeat the basic elements of form, line, color, and texture found in the natural features of the landscape within the foreground distance zone. Successful mitigation in the foreground distance zone would include locating facilities to utilize the terrain and vegetation to screen them from the highways. If the implementation of mitigation measures would not enable facilities to meet Class II objectives, one of the following two options must be implemented to comply with BLM management objectives: 1) the facilities would be relocated to a site outside of the VRM Class II area on BLM lands; and 2) the BLM RMP would be amended to change the affected VRM Class II areas to VRM Class III areas.

There are three CBM wells and one compressor station proposed for BLM lands inventoried with VRM Class V. The proposed facilities on BLM lands would be consistent with BLM management objectives for VRM Class V areas, which provide for areas where the natural character has been drastically altered.

The Buffalo Field Office has developed a management decision to implement the management objective of maintaining or improving scenic values, visual quality, and establish visual resource management priorities in conjunction with other resource values. Visual resources are to be managed in accordance with objectives for VRM classes that have been assigned to the planning area, which constitutes most of the Project Area. No activity or occupancy is allowed within 200 feet of the edge of state and federal highways. Facilities or structures such as power lines, oil wells, and storage tanks are required to be screened, painted, and designed to blend with the surrounding landscape except where safety indicates otherwise. Any facilities or structures proposed in or near WSAs would be designed so as not to impair wilderness suitability.

BLM lands in the Fortification Creek WSA and the Fortification Creek SMA are inventoried with VRM Class III. The WSA has an NSO for mineral development. The Fortification Creek SMA, which encompasses the WSA, has a CSU stipulation to protect scenic values. Proposed facilities in the SMA must meet Class III objectives to protect scenic values. There is potential that Class III objectives would not be met because the facilities would not be subordinate to the existing landscape character. BLM objectives for some Class III facilities would be met if

every attempt were made to minimize adverse visual effects through careful location of facilities, minimal disturbance of the site, and painting of facilities so they harmonize with the colors of the surrounding landscape. No facilities are proposed for the WSA because of the NSO, however, to ensure the scenic integrity of the WSA, a buffer that excludes any CBM development should separate the WSA from the surrounding SMA.

The Cantonment Reno and Weston Hills Recreation Area are inventoried with VRM Class IV. No project facilities are proposed for location within these two SMAs. Indirect effects to recreational uses of the SMAs would occur because landscapes outside of these areas would be modified by the addition of project facilities, which would affect the recreational experience of visitors to the SMAs. CBM wells proposed for lands adjacent to the Cantonment Reno and Weston Hill Recreation Area would be visible to viewers in the areas. BLM Class IV objectives for the SMAs and adjacent lands would be met.

Long-term visual effects would be minimized by designing permanent structures to harmonize with the surrounding landscape to the extent feasible, recontouring and revegetating disturbed areas no longer needed for operations as soon as practicable, and by reshaping straight edges of clearings resulting from roads, pipelines, well pads, and compression facilities to create irregular or indistinct edges. Construction debris would be removed immediately because it creates undesirable textural contrasts with the landscape. In addition, resource protection measures proposed for erosion control, road construction, rehabilitation and revegetation, and wildlife protection would be implemented during the approval of APDs and Sundry Notices. These measures also would mitigate effects to visual quality.

Forest Service (Thunder Basin National Grassland)

There are 437 wells distributed on 397 well pads proposed for federal lands administered by the Medicine Bow National Forest within the Thunder Basin National Grassland. Most of the federal lands on that portion of the TBNG that is within the Project Area are managed with the SIO of Low. A small portion of the TBNG within the Project Area is managed with the SIO of Moderate. The TBNG lands managed with Moderate SIO are along Antelope Creek or are in an area outside of the coal boundary. No wells are proposed for TBNG lands managed with the SIO of Moderate. All of the proposed 437 wells are on TBNG lands managed with the Low SIO.

Scenery Management guidelines for the TBNG are to manage activities to be consistent with the SIOs and to rehabilitate areas that do not meet the SIOs specified for the management area. Visual management objectives for SIOs are associated with desired landscape character for each management area and are based on the intent of the management area direction. Facilities are proposed for three of the seven management areas within the Project Area. Management Areas 3.68 (Big Game Range) and 6.1 (Rangeland with Broad Resource Emphasis) on which facilities are not managed with goals for a desired condition for scenic values. The SIO for these areas is Low. Few facilities are proposed for these areas. The majority of wells and ancillary facilities are proposed for Management Area 8.4 (Mineral Production and Development). The desired condition for landscapes in

this management area is that facilities and landscape modifications can be visible, but are reasonably mitigated to blend and harmonize with natural features.

State and Private Lands

There are 2,744 wells distributed on 1,739 well pads and 14 compressor stations proposed for State lands in the Project Area. Mineral leases administered by the Wyoming Office of State Lands and Investments do not include guidance on the management of visual or scenic resources on state-owned lands in the Project Area. According to rules and regulations of the Board of Land Commissioners, upon completion of operations on state lands, all related disturbances on state lands must be reclaimed to leave the land in as near as practicable to the original condition of the land before operations.

Most of the proposed facilities would be located on private lands. There are 30,573 wells (77.8 percent of total proposed wells) distributed on 20,400 well pads (78.5 percent of proposed well pads) and 126 compressor stations (68 percent of total number of compressor stations) proposed for private lands in the Project Area. The majority of effects to the landscape would occur on private land because most wells are located on private land and most of the land within the viewsheds of communities, rural residential areas, and transportation routes is private land.

Counties

The Sheridan County Growth Management Plan identifies the need for an inventory of existing resources, including scenic resources, and the utilization of this information in the review and evaluation of proposed developments. Currently no procedure or ordinance exists that provides for evaluation and review.

The Comprehensive Planning Program jointly developed by the City of Gillette and Campbell County recommends that landscaping should be developed into the buffer zones where industrial areas are located adjacent to residential areas. There are numerous CBM wells proposed for lands adjacent to residential areas in subdivisions located outside of the Gillette municipal boundaries.

Non-CBM Development

The moderate level of conventional oil and gas development as evaluated under the BLM's RFD scenario projects the drilling and completion of 3,000 non-CBM wells within the Buffalo Field Office's portion of the Project Area over the 10-year period. Surface disturbances required for conventional wells are greater than those required for the new CBM wells as described earlier in this section. Short-term surface disturbances for well pads and associated improved access roads range from 0.5 acres for shallow gas wells to 5.5 acres for a typical deep oil well. Long-term disturbances would encompass about 82 percent of the original disturbance.

Non-CBM facilities consist of pump jacks, in contrast with CBM facilities, which consist of a wellhead contained in a metal box. The components with the highest potential to adversely affect the surrounding landscape character are the well pad clearings, the improved access roads, and the pump jacks. The operation

of the proposed facilities would introduce new elements of form, line, color, and texture into the landscape; would essentially dominate foreground views; and would be obvious in middleground and background views. Effects would be similar to those described for CBM well facilities; however, each well pad and associated access road would disturb a larger number of acres.

The alignment of individual pump jacks with respect to viewing areas, such as residential areas, individual residences, and transportation routes, should be reviewed during the pre-installation phase of well development. In general, each pump jack should be aligned parallel to a road unless it has been determined that this type of alignment is not feasible. Facilities would be the most visible to travelers on the road during that period of time when the facility is within the line of sight as they travel towards the facility. Aligning pump jacks parallel to roads would present travelers with a smaller surface area as the traveler approaches the facility. In addition, pump jacks with the lowest possible profile should be used when feasible.

Alternative 2

Alternative 2 differs from Alternative 1 in the distribution of produced water among the methods for handling produced water, and the compression of gas. Alternative 2A emphasizes the use of infiltration impoundments to dispose of produced water, while Alternative 2B emphasizes the use of passive and active treatments. The number and distribution of CBM and non-CBM conventional wells is the same as evaluated for the Alternative 1. The impacts to the characteristic landscape from the development of CBM well and the ancillary facilities other than facilities for handling produced water is identical to those described for the Alternative 1.

Alternative 2A or Alternative 2B would result in the disturbance of more surface acres (39,367 acres) than Alternative 1 or Alternative 3. For both Alternatives 2A and 2B, the largest disturbances would occur from infiltration impoundments (32,253 acres under Alternative 2A and 23,446 acres under Alternative 2B). The operation of infiltration impoundments under Alternative 2A would affect 121 percent more surface land that impoundments proposed for Alternative 1. Alternative 2B would affect 61 percent more surface land that Alternative 1. The impact to the visual quality of the landscape is substantially larger from Alternatives 2A or 2B than for the proposed Alternative 1. The impoundments would be located outside of transportation corridor and residential area viewsheds, and would primarily affect lands inventoried with VRM Class IV.

Under Alternatives 2A and 2B, LAD sites would affect 6,296 acres of land in the Project Area, an increase of 254 percent over the LAD sites proposed for the Proposed Action. The containment reservoirs would affect approximately 2,583 acres under Alternative 2A or 2,148 acres under Alternative 2B. Alternative 2A would be an increase of 14.9 percent over the Proposed Action, primarily within VRM Class IV areas. Alternative 2B would be a decrease of four percent from the Proposed Action. The large increase in LAD sites over the Proposed Action would result in larger areas of modified vegetation as described for the Proposed Action. The number of acres disturbed by containment reservoirs

would not be substantially different from the Proposed Action, and would result in a similar level of visual impact. The effects of injection wells and surface discharge to the landscape would be minor. A total of 39,367 acres would be affected from these water-handling methods proposed for Alternative 2A or Alternative 2B, which is more than 20 percent greater than the total 32,685 acres that would be affected under the Proposed Action.

Alternative 3

Under the No Action alternative, there would be no CBM development on federal leases within the Project Area. Federal leases are located on private as well as federal lands. Development would continue on State and private leases. A total of 15,458 CBM wells would be developed on State and fee leases. The No Action alternative includes all of the effects to visual resources described for Alternative 1, but differs from Alternative 1 in the number of wells to be developed, the acres of land to be disturbed temporarily or removed from existing uses during the life of the Project, and the volume of water to be produced from CBM wells. The effects to the characteristic landscape from the No Action alternative would considerably less than those described for the Proposed Action because 15,458 CBM wells proposed for State and fee mineral leases is approximately 39 percent of the total 39,367 new CBM wells under the Proposed Action. Table 4–98 summarizes the long-term disturbance by VRM Class for each sub-watershed. Although proposed CBM wells on state and fee lands are not managed for BLM's VRM objectives, the inventory provides an assessment of the existing scenic quality and the ability of these lands to absorb effects to the landscape from development activities.

Because there are fewer wells proposed for the Project Area, there would also be a considerably smaller number of facilities proposed for the distribution of produced water under the No Action alternative. LAD sites would affect 808 acres of land in the Project Area, a decrease of 55 percent from the LAD sites proposed for the Alternative 1. The containment reservoirs would affect approximately 2,159 acres, a decrease of 58 percent from the Alternative 1. The effects of injection wells and surface discharge to the landscape would be minor. A total of 15,458 acres would be affected from all water-handling methods proposed for this alternative, which is about 83 percent less than the total 32,685 acres that would be affected under the Alternative 1.

Cumulative Effects

The cumulative well development scenario is comprised of the 39,367 wells under the Proposed Action and 12,077 CBM well already drilled or permitted within the Project Area. Table 4–99 summarizes the long-term disturbance by VRM Class for each sub-watershed.

Table 4–98 Alternative 3 Wells and Well Pads in VRM Classes by Sub-Watershed in the Powder River Basin Project Area

	Class II			Class III			Class IV			Class V			Total		
Sub-watershed	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Total Proposed Wells	Total Proposed Pads	Long Term Pad Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	130	44	101	345	189	432	1,683	740	1,692	0	0	0	2,158	973	2,225
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	146	93	1486	661	390	6230	3,629	2,356	37,636	0	0	0	4,436	2,839	45,352
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	19	19	7	0	0	0	19	19	7
Crazy Woman Creek	0	0	0	183	183	662	751	446	1,614	0	0	0	934	629	2,277
Clear Creek	120	114	453.9	841	506	2015	1,527	1,120	4,459	0	0	0	2,488	1,740	6,928
Middle Powder River	0	0	0	0	0	0	201	97	80	0	0	0	201	97	80
Little Powder River	0	0	0	14	9	41.8	800	509	2,363	145	134	622	959	652	3,027
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	40	32	517	563	494	7,987	0	0	0	603	526	8,504
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	236	236	172	24	24	17	260	260	189
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	574	502	3963	2,705	2184	17,241	121	121	955	3,400	2,807	22,160
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	396	251	2,040	2,658	1,811	13,862	12,114	8,201	73,251	290	279	1,595	15,458	10,542	90,748

Note: Disturbance acres for well pads include the disturbance associated with ancillary facilities such as roads, compressors, and transmission lines. Totals may not match precisely with values obtained by adding unit numbers or with distributions of pads and wells presented in Chapter 2 due to rounding conventions.

Table 4–99 Cumulative and Well Pads in VRM Classes by Sub-Watershed in the Powder River Basin Project Area

Sub-watershed	Class II			Class III			Class IV			Class V			Total		
	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Total Proposed Wells	Total Proposed Pads	Long Term Pad Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	486	190	434	444	247	565	2,474	1,098	2,511	0	0	0	3,404	1,535	3,510
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	964	581	9,282	2,831	1,623	25,927	17,980	11,891	189,954	0	0	0	21,775	14,095	225,162
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	37	37	14	0	0	0	37	37	14
Crazy Woman Creek	0	0	0	540	443	1,604	2,530	1,518	5,495	0	0	0	3,070	1,961	7,098
Clear Creek	199	192	764	1,141	678	2,700	2,802	1,943	7,736	0	0	0	4,142	2,813	11,199
Middle Powder River	0	0	0	0	0	0	1,685	899	744	0	0	0	1,685	899	744
Little Powder River	0	0	0	37	31	144	3,373	2,175	10,098	438	360	1,672	3,848	2,566	11,913
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	92	84	1,358	1,805	1,618	26,159	0	0	0	1,897	1,702	27,517
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	920	860	626	67	62	45	987	922	671
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	1,261	1,134	8,952	9,160	7,749	61,174	172	170	1,342	10,593	9,053	71,468
Middle North Platte Casper	0	0	0	0	0	0	6	0	0	0	6	1	6	6	1
Total	1,649	963	10,480	6,346	4,240	41,249	42,772	29,788	304,509	677	598	3,060	51,444	35,589	359,298

Note: Disturbance acres for well pads include the disturbance associated with ancillary facilities such as roads, compressors, and transmission lines. Totals may not match precisely with values obtained by adding unit numbers or with distributions of pads and wells presented in Chapter 2 due to rounding conventions.

The cumulative effect on the landscape would consist of existing, permitted, and proposed CBM development on federal, State and private lands in the Project Area, and existing, proposed, and reasonably foreseeable coal mining in the Project Area. The cumulative effect of all existing and proposed development would result in a larger number of disturbed acres from well pads and access roads that may be visible from transportation routes and recreation areas. Ongoing CBM development on federal, State, and private lands would increase the industrial character of those areas that include considerable modification from other oil and gas activities and from coal mining, and change the visual character of the predominantly rural landscape in much of the Project Area to rural/industrial.

A principal visual effect in the eastern part of the Project Area and near the city of Sheridan is the visibility of coalmine pits and facility areas. However, anyone likely to see these facilities would either be passing through the area or visiting on related business. After mining, the reclaimed slopes might appear somewhat smoother than pre-mining slopes and there would be fewer gullies than at present. Even so, the landscape of the reclaimed mines would look very much like undisturbed landscape in the area. Except from the air, energy development activities, including CBM development, are not visible from more than a few miles away.

Recreational Resources

The potential effect of the construction and operation of the proposed facilities on recreational resources is related to how much recreational opportunity is being created by the Project versus how much opportunity is being lost for recreational pursuits. Local residents value the federal lands for recreational activities because of the proximity to their homes and the relative solitude that can be achieved within a short distance from their homes. The recreational issue identified in the scoping process is the effects of the additional development of oil and gas resources on recreational opportunities and the recreational experience.

Alternative 1

The Proposed Action would be constructed and operated on federal, State, and private lands. The primary effect of the CBM development on recreational opportunities would be the alteration of the recreational experience on federal and State lands used for hunting. To some degree, additional development of oil and gas resources would alter the existing recreational setting and experience. The Project Area is predominantly rural in character with some industrial-type modifications from existing wells.

Direct effects to recreation occur when recreational opportunities are enhanced, limited, or curtailed within an area; when recreational uses are created, displaced, or eliminated by proposed CBM facilities; or if federal, state, or county objectives for recreation cannot be met. Effects to recreational resources occur if recreational facilities undergo substantial change or degradation.

Direct effects to recreational uses in the Project Area would occur because additional wells would add new industrial features to the landscape and new sources

of noise that could diminish the recreational experience and affect the rural ambience sought by recreationists. The construction and operation of the proposed facilities also could affect recreational activities by changing access opportunities and by directly disrupting recreational activities. New roads would provide access for vehicles and promote an increase in human activity. Additional development could adversely affect hunting, viewing of wildlife, and fishing. Development of certain facilities, such as reservoirs for impounding produced water, could enhance some wildlife-related recreational opportunities by providing areas for viewing wildlife, hunting waterfowl, or public fishing.

Indirect effects to recreation would occur if the Project resulted in a change in the level of visitation to the area or if the Project would affect growth in the affected counties, thereby changing the utilization of existing recreational facilities and uses. No developed recreation sites would be impacted by the Proposed Action. Therefore, visitation to these sites would not be affected by the Proposed Action. Hunting may be affected in some game management units. The Project is not expected to affect the level of visitation and population growth in the counties. It is anticipated that the existing workforce would be sufficient to provide adequate personnel for the construction and operation of proposed CBM facilities; therefore, there would be no growth in population from in-migration and no increase in the demand for recreation opportunities.

Construction Disturbance

Short-term effects to recreation within the Project Area would result from all phases of the construction process. Activities associated with the installation of the proposed wells, including construction of roads, pipelines, power lines, and other ancillary facilities, would alter the use of affected roads for the duration of construction activities. Construction activities can be expected to occur over a period of 10 years over the entire Project Area. It is anticipated that the annual construction period would be seven days per week over the entire year, or 365 days, depending on weather and soil conditions. During this period, there would be disturbance to the existing landscape character, and noise and dust from construction activities. These activities would potentially conflict with recreational uses because they would be visually and audibly apparent to the recreational experience. The effects to the existing land uses from drilling are site specific and would occur at specific locations for no more than three days per drill site throughout the 10-year drilling period. Some sites would be reclaimed back to the permanent disturbance areas prior to construction at other sites.

In addition to the disturbances created by construction on the site, there would be traffic associated with moving equipment over public highways and local roads. Traffic-related effects are evaluated in the Transportation section. Access roads would be constructed to connect CBM facilities with highways and local roads. A total of 17,276 miles of improved roads and two-track roads would be constructed in the Project Area. Road construction is expected to average one day per mile, or a total of approximately 17,276 days. The construction would occur over the ten-year period as required to access wells. Recreationists would encounter road construction over the entire year at specific locations within the Project Area. The loss of solitude and the natural experience would affect local users in the particular area of construction.

Pipeline installation along existing road rights-of-way is likely to inconvenience recreationists who use the roads to gain access to recreational activities in the area. Construction activities would also limit recreational use of existing roads and trails, as well as degrade the visual quality of the recreational experience. The loss of solitude along these roads would continue through the construction period. Road access is likely to be restored to existing uses within a few days to a few months, once construction or installation activities have been completed. The recreational opportunities for local residents in close proximity to proposed activities would be altered during the construction period.

Project construction would result in increased noise levels from heavy equipment in surrounding areas. Construction-related noise could reduce the quality of the recreational experience in general. However, construction-related increases would be short-term and with the exception of blasting, generally restricted to the immediate vicinity of the work. Noise from blasting would be sporadic and of short duration. There are potential long-term increases in noise levels from the operation of the compressors.

The general season dates for big game hunting (all types of big game in all units) occur from late September/early October through late November. The hunting season would be affected by construction activities for the ten-year construction period, but only at specific locations where construction activities are scheduled.

Permanent Disturbance

Long-term effects to developed and dispersed recreational uses of the Project Area would occur as the displacement of acreage from existing uses by proposed CBM facilities. The primary effects would be an alteration of the recreational experience for residents and visitors to the Project Area. Recreational activities displaced by project facilities are likely to add increased use on adjacent federal and State lands.

Dispersed Recreation

Dispersed recreational opportunities in the affected counties include hunting, fishing, sightseeing, and camping. Dispersed recreation, with the exception of hunting, is not a primary use of most federal, State or private lands that are within the coal boundary of the Project Area. There is expected to be little change in existing levels of dispersed recreational activities on federal and State lands in most of the sub-watersheds within the Project Area as a result of CBM development under the Proposed Action. Existing levels of recreational activity are expected to continue on these lands. Most of the proposed activity would occur in the Upper Powder River, Little Powder, and Upper Belle Fourche sub-watersheds.

Hunting is the principal recreational activity on federal, State, and private lands in the Project Area. The acreage removed from wildlife habitat by project facilities under the Proposed Action is not likely to adversely affect hunting and fishing opportunities within the Project Area. Recreational hunting and fishing opportunities, which are controlled by landowners on private lands, may increase locally within the Project Area, as populations of game animals and game fish rise locally during the life of the Project, in response to increased availability of

surface water and forage. However, increased access and human activity associated with CBM development may adversely affect wildlife populations that support various recreational activities.

Big game populations in big game management units west of I-25 and in other units outside of the coal boundary would not be affected by Project activities. Units that would be affected contain portions of one or more sub-watersheds with proposed CBM development. The largest effects to hunting would occur in the Upper Powder, Upper Belle Fourche, Little Powder, Clear Creek, Antelope, and Crazy Woman Creek sub-watersheds because most CBM development would occur in these sub-watersheds. These sub-watersheds contain portions of ten antelope game units (56 percent of total antelope game units in the Project Area), ten deer game units (45 percent of total deer game units), and two elk game units (22 percent of total elk game units). Table 4–100 summarizes the number of participating hunters, total hunter days, and non-resident hunters for the big game management units that would be affected by the proposed CBM development in the Project Area. A total of 12,866 active hunters or nearly 47 percent of the total estimated 27,491 active hunters in the Project Area potentially would be affected by the removal of wildlife habitat and the intrusion of project-related noise, dust, and visual effects from the proposed CBM development in addition to positive effects related to increased access and the potential rise in game and fish populations.

Table 4–100 Big Game Hunting in the Powder River Basin Project Area, 2000

Game Unit	Active Hunters	Total Harvest	Hunter Success (percent)	Hunter Days	Non-Resident Hunters	Percent Non-Resident Hunters
Antelope	4,292	3,907	91.0	10,512	3,276	76.3
Deer	8,347	5,158	61.8	27,695	4,449	53.3
Elk	227	152	67.0	715	31	13.7

Source: Wyoming Game and Fish Department, 2001

The development of roads and well facilities would result in greater physical access to the Project Area and potentially increase hunting pressures on wildlife. However, a majority of this access would be not be available to the public because much of the surface within the Project Area is privately owned.

Several streams and lakes in the Project Area are used for year-round fishing by local recreationists. All affected fishing areas are within sub-watersheds that would be developed with proposed CBM facilities. Effects to fish and their habitats are evaluated in the Wildlife section.

The operators have stated they would work with landowners in the Project Area to enhance the use of the good quality, discharged water. This practice may promote the impoundment of discharged water and use for wetlands and/or fisheries development. Given the potential quality of discharged water associated with the Project in some sub-watersheds, it is reasonable to conclude that enhanced vegetation and increased water availability probably would have some beneficial ef-

fects on fish and wildlife and their habitats and may enhance recreational opportunities in the immediate vicinity of any reservoirs created. This would continue until water production ceases. Water handling facilities would be constructed in sub-watersheds with low water quality for produced water in order to prevent potentially adverse effects on surface water and fish habitat.

Produced water from CBM wells would be discharged by four methods: surface discharge at outfalls, containment in large upland evaporation reservoirs, spread on the land surface at LAD sites, or injected at an injection well. Effects to recreation from the proposed 323 injection wells would be similar to those described for CBM production well facilities. About 27 LAD sites occupying 1,728 acres would result in large areas of modified vegetation. Development of LAD sites would potentially have an adverse effect on wildlife, and consequently, hunting opportunities in the affected sub-watersheds because the modified vegetation may affect the quality of the wildlife habitats. There are 142 containment reservoirs occupying 19,880 acres proposed for upland areas. Containment reservoirs would create opportunities for some wildlife-related recreational opportunities by providing areas for viewing wildlife, hunting waterfowl, or public fishing. The recreational experience also would be affected by the visual impact of the proposed water handling facilities.

Developed Recreation Areas and Recreation Sites

There are no CBM facilities proposed for developed recreational areas or recreational sites in the Project Area. Most of the developed recreational areas identified in Chapter 3 are located in the western part of the Project Area outside the coal boundary. Special management areas that are on federal lands administered by the BLM are discussed in the section evaluating effects to BLM management of federal lands in the Project Area.

BLM Recreation Management

Some federal lands administered by the BLM in the Project Area that include developed recreational sites or recreational activities have specific resource values that put them under No Surface Occupancy (NSO) mitigation guidelines. Lands managed with NSO include Recreation Areas, such as campgrounds, historic trail, and national monuments, and special management areas, such as areas suitable for consideration for wild and scenic rivers designation.

The BLM administers federal lands in the Middle Fork Recreation Area, the Red Wall/Hole-in-the-Wall area, Outlaw Cave Recreation Site (or Cultural Area), Dull Knife Battlefield site, and the Gardner Mountain and North Fork Wilderness Study Areas. There would be no effects to recreational uses of these special management areas because they are located ten miles or more outside of the coal boundary in the Middle Fork Powder Watershed. With the exception of the Middle Fork Recreation Area, these areas have NSO leasing stipulations for mineral development. There would be no effects to the landscape within or near these areas.

The Fortification Creek WSA and the Cantonment Reno, located in the Upper Powder River sub-watershed, each have NSO for mineral development. The Weston Hills Recreation Area, located in the Little Powder sub-watershed north

of Gillette, does not have any NOS leasing stipulation. However, no project facilities are proposed for location within the Recreation Area. Indirect effects to recreational uses would occur as landscapes outside of the areas would be modified by the addition of project facilities and would affect the recreational experience of visitors to these areas. CBM wells are proposed for lands adjacent to Fortification Creek WSA and Weston Hill Recreation Area and would be visible to viewers in the areas.

Private and State Lands

Recreation is not a significant use of most private lands in the Project Area. Most developed recreation on private lands is municipal facilities in Project Area communities. CBM facilities are proposed for private and State lands outside of and adjacent to Gillette. Recreational facilities that are located on these lands include the Cam-Plex and the Cam-Plex Park. The Cam-Plex facilities occupy about 1,000 acres at the east side of Gillette, and include a theater, a convention/exhibit hall, two large multi-purpose pavilions, rodeo grounds, RV campgrounds, a horse race track, a 21-acre park, and picnic area. The development of CBM facilities would not be compatible with public use of these facilities.

Other recreational facilities located near the municipal boundaries and near to proposed facilities include the Dalby Memorial Park, the Country Club Golf Course, and the Bell Knob Golf Course. These facilities would experience indirect effects from the Project because the recreational experience would be affected by the sight and noise of CBM construction and operation. There are no other recreational sites on private lands or within municipal boundaries that would be affected by Project activities.

Developed recreational opportunities on State lands include big game hunting in the Amsden Creek Winter Game Refuge and the Bud Love Wildlife Habitat Management Area. Both areas are managed with NSO leasing stipulations and would not be impacted by Project activities.

Alternative 2

Alternative 2 differs from Alternative 1 in the distribution of produced water among the methods for handling produced water and the compression of gas. The numbers and distribution of CBM and non-CBM wells are the same as evaluated for the Proposed Action. The effects to the developed and dispersed recreational uses from the development of CBM wells and the ancillary facilities other than facilities for handling produced water is identical to those described for the Proposed Action.

Under Alternative 2, there would be 76 LAD sites in the Project Area, an increase of 181 percent over the LAD sites proposed for the Proposed Action. The proposed 117 containment reservoirs would be a decrease of 18 percent from the Proposed Action. The large increase in LAD sites over the Proposed Action would result in larger areas of modified vegetation as described for the Proposed Action. Development of additional LAD sites would potentially have an adverse effect on wildlife and, consequently, hunting opportunities in the affected subwatersheds because the modified vegetation would affect the quality of the wild-

life habitat. The smaller number of containment reservoirs would reduce the opportunities for some wildlife-related recreational opportunities relative to the opportunities resulting from the Proposed Action by providing areas for viewing wildlife, hunting waterfowl, or public fishing. There would be a larger potential for adverse impact to recreational opportunities in the Project Area from Alternative 2.

Alternative 3

Under the No Action alternative, there would be no CBM development on federal leases within the Project Area. Federal leases are located on private as well as federal lands. Development would continue on State and private leases and would include access and pipelines across federal lands to reach proposed State and fee wells. There would be a total of 15,458 CBM wells developed on State and private leases. The No Action alternative includes all of the effects to recreational opportunities and the recreational experience described for the Proposed Action, but differs from the Proposed Action in the number of wells to be developed, the acres of land to be disturbed temporarily or removed from existing uses during the life of the Project and the volume of water to be produced from CBM wells. The effects to recreation are expected to be considerably less than those described for the Proposed Action because a small number of facilities would be developed and a small number of acres would be removed from existing uses. Tables 2–29 through 2–32 summarize the facilities proposed for Alternative 3 and the short- and long-term disturbance for each sub-watershed.

Under Alternative 3, there would be 13 LAD sites in the Project Area, a decrease of 52 percent from the LAD sites proposed for the Proposed Action. The proposed 68 containment reservoirs would be a decrease of 52 percent from the Proposed Action. The Fewer LAD sites would result in smaller areas of modified vegetation than described for the Proposed Action. There would be a lesser effect on wildlife than the Proposed Action. The smaller number of containment reservoirs would reduce the opportunities for some wildlife-related recreational opportunities relative to the opportunities resulting from the Proposed Action by providing areas for viewing wildlife, hunting waterfowl, or public fishing. There would be a lesser potential for adverse effects to recreational opportunities in the Project Area from Alternative 2 than would occur from the Proposed Action.

Cumulative Effects

The cumulative effect of the development of roads and well facilities would be improved vehicular access to the area. However, a majority of this access would be not be available to the public since much of the surface is privately owned and there are no recreational facilities.

The cumulative acreage likely to be affected long-term by production facilities under the Proposed Action (approximately 6,514 acres) is not likely to have a cumulative effect on hunting and fishing opportunities. Recreational hunting and fishing opportunities, which are controlled by landowners on private lands, may increase locally within portions of the area, as populations of game animals and game fish rise locally during the life of the Project in response to increased avail-

ability of surface water and forage. This small cumulative enhancement of recreational opportunities in the immediate vicinity of any reservoirs created would be temporary and would last only as long as water production continues. Although the Project is not expected to affect the level of visitation or growth in the counties, recreation visitors may become accustomed to recreational experiences near ponds or flowing water over the life of the Project. Visitors would have to accept anticipated reductions in surface water when water discharge ends.

Cumulative effects from the increased human presence associated with the cumulative energy development in the PRB are likely to cause increased levels of legal and illegal hunting. Conversely, the mines in the area have become refuges for big game animals during hunting seasons since most are closed to hunting.

Energy development-related secondary effects to recreational land uses have and would continue to result from human population growth. The demand for outdoor recreational activities, including hunting and fishing, have increased proportionately. However, at the same time these demands are increasing, wildlife habitat and populations are being affected by increased surface disturbance.

Demand for hunting licenses may increase to the point that a lower success in drawing particular licenses would occur; hunting and fishing may become less enjoyable due to more limited success and overcrowding; poaching may increase; the increase in people and traffic has and may continue to result in shooting of nongame species and road kills; and increased off-road activities have and would continue to result in disturbance of wildlife during sensitive wintering or reproductive periods. Travel management during hunting season, including seasonal road closures to the public, could disperse hunters throughout the area, reduce hunting pressure in popular areas, and facilitate a more enjoyable experience for hunters.

It is not anticipated that the Proposed Action and proposed CBM development on State and private lands would result in any increase in population because the proposed workforce would consist of local hires. However, the overall population of Project Area counties may increase as a result of future coal mine development and expansion of existing mines. CBM fields may continue to be developed within the Project Area and may contribute to ongoing population growth. Any future growth may contribute increased visitor use of the developed facilities.

Noise

The EPA (EPA, 1974) has established an average 24-hour noise level as the maximum noise that does not adversely affect public health and welfare. No definitive data has been established concerning noise levels that affect animals. No laws concerning quantitative noise levels have been established by the State of Wyoming or the BLM. Therefore, lacking any quantitative statutory guidelines, noise levels above 55 dBA at a residence, school, medical facility, or a special recreation area are considered a noise impact.

Noise levels would be temporarily elevated above the general rural background noise of 35 to 40 dBA during the construction of facilities. Construction-related noise would result from construction equipment, vehicle traffic, and drilling rigs. However, activities at each drill site would occur for only one to five days during the short drilling period. Therefore, well pad construction would not cause any significant noise impacts. Construction related noise would last longer for the 60 to 90 days required to construct a compressor station or less for pipeline construction. However, the noise from each construction site would be relatively short-term and the individual sites would be sufficiently widespread so that elevated noise levels from each site would not overlap in time or space with another site.

The highest operational noise would occur around compressor stations. Under all alternatives, two types of compressor engines would be installed. Small booster compressor engines rated at 350 horsepower would be operated to gather natural gas from wells to the larger compressor stations. A maximum of six booster compressor engines could be operated at any location. At the larger compressor stations, large reciprocating engines rated at 1,650 horsepower would be installed to facilitate transmission of natural gas to high-pressure transmission pipelines. Typically, three or six of the larger engines would be installed at any location.

Noise has been measured at typical compressor units (USGS, 1981). A noise level of 77 dBA from one large compressor engine can be expected at 50 feet from a compressor building since all compressors would be installed in enclosed buildings because of the harsh Wyoming winter weather. Noise from the smaller booster compressor engines would be slightly lower or approximately 73 dBA at 50 feet.

The effect of multiple noise sources is not arithmetically additive, but rather is a logarithmic addition. The total effect of multiple co-located noise sources is characterized by the following relationship (Harris, 1991):

$$L = 10 * LOG (10^{L1/10} + 10^{L2/10} + ... + 10^{Ln/10})$$

where: L1, L2, ..., Ln are the source sound levels of individual collocated sources.

L is the overall noise level.

LOG is the common logarithm base 10.

Therefore, the preceding equation is used to calculate the overall noise of six large compressor engines operating simultaneously with a source noise of 77 dBA from each engine. The resultant overall source noise would be 84.8 dBA at 50 feet from the enclosure building. The overall noise from a compressor station with three engines would be 81.8 dBA at 50 feet. For the smaller booster engines, the overall noise would be 80.8 dBA at 50 feet for six engines, and 77.8 dBA at 50 feet for three engines.

To calculate the noise impact at a distance from the compressor station, the noise levels were mathematically propagated using the Inverse Square Law of Noise

Propagation (Harris, 1991). Briefly, this formulation states that noise decreases by approximately 6 dBA with every doubling of the distance from the source. This methodology is an accurate assessment of noise propagation and is represented as:

$$L_2 = L_1 - 20 \log (R_2/R_1)$$

where:

L_2 = noise level at a selected distance R_2 from the source

L_1 = noise level measured at a distance R_1 from the source.

The preceding equation was applied for the source noise for configurations of three and six engines at a compressor station for both types of compressors. Table 4–101 shows the noise levels at selected distances from the two types of compressor engines with three- or six-engine configurations. The bolded noise levels correspond to the approximate distance where the noise produced by the compressor stations would be less than 55 dBA. As long as compressor stations would be constructed at least this distance from existing residences, no significant noise impact would occur at the residence. Compressor stations would have to be constructed further from grouse leks to ensure noise from the stations would be less than 49 dBA.

Table 4–101 Predicted Noise Levels from PRB Compressor Stations

Distance (feet)	Noise from 6 Large Engines (dBA)	Noise from 3 Large Engines (dBA)	Noise from 6 Booster Engines (dBA)	Noise from 3 Booster Engines (dBA)
200	72.8	69.8	68.8	65.8
400	66.7	63.7	62.7	59.7
600	63.2	60.3	59.2	56.2
800	60.7	57.7	56.7	**53.7**
1,000	58.8	55.8	**54.8**	51.8
1,200	57.2	**54.2**	53.2	50.2
1,400	55.9	52.9	51.9	48.9
1,600	**54.7**	51.7	50.7	47.7
1,800	53.7	50.7	49.7	46.7
2,000	52.8	49.8	48.8	45.8

Socioeconomics

Alternative 1

Effects to the socioeconomic structure of Campbell, Converse, Johnson, and Sheridan counties, including population, housing, and employment, resulting from drilling and constructing ancillary facilities, such as roads and pipelines, are expected to occur over a 10-year period under the Proposed Action. The socioeconomic effects resulting from CBM production activities are expected to occur over the proposed life to the Project, about 20 years. The number of CBM wells

are provided in Table 4–102 and the number of non-CBM wells are provided in Table 4–103.

Table 4–102 CBM Wells Proposed by Mineral Ownership

	Number of Wells Drilled on Federal	Number of Wells Drilled on State	Number of Wells Drilled on Fee	Total
Campbell	13,448	1,018	6,834	21,300
Converse	114	20	42	176
Johnson	7,764	756	2,260	10,780
Sheridan	2,583	874	3,654	7,111
Total	23,909	2,668	12,790	39,367

Table 4–103 Non-CBM Wells Proposed by Mineral Ownership

	Number of Wells Drilled on Federal	Number of Wells Drilled on State	Number of Wells Drilled on Fee	Total
Non-CBM Proposed by Mineral Ownership				
Converse	120	9	71	200
Johnson	176	18	59	253
Sheridan	18	7	45	70
Total	1,855	214	1,131	3,200

Most of the production is expected to occur in Campbell and Johnson counties. For this reason, Campbell County and Johnson County are likely to be affected by fiscal and social effects. Sheridan County also would have extensive effects and all three counties would have a greater extent of effects than Converse County. Most of the new wells (63 percent) and facilities would be constructed in the two sub-watersheds, the Upper Powder River sub-watershed, which is within approximately one-third of Campbell County and two-thirds of Johnson County, and the Upper Belle Fourche sub-watershed, which is within Campbell County. Other sub-watersheds with relatively high numbers of wells and facilities include: the north portion of Clear Creek and Upper Tongue River, which are within Sheridan County; Crazy Woman and the south portion of Clear Creek, which are within Johnson County; and Little Powder, which falls in Campbell County. Most of the employees are likely to primarily reside in Gillette and Wright, but employees also would live in Sheridan, Buffalo, and other smaller communities within the Project Area.

Socioeconomic effects resulting from CBM development are a concern because considerable energy-related development has occurred in and around the affected counties during the past 30 years. Wyoming's economy has been structured around the basic industries of extractive minerals, agriculture, tourism, timber, and manufacturing. Many Wyoming communities depend on the mineral industry for much of their economic well being. The 1999 assessed valuation on all min-

erals produced in Campbell, Converse, Johnson, and Sheridan counties accounted for 36.9 percent of the State of Wyoming's total assessed valuation (WDR 2001). In the same year, assessed valuation on minerals produced in the State accounted for 32 percent of the State's valuation (Powder River CBM Information Council 2001).

Several forecasts have been developed for future natural gas supply and demand in the PRB. The State of Wyoming's Consensus Revenue Estimating Group (CREG) develops mineral price and production forecasts for major mineral commodities twice each year to estimate the State's anticipated revenues. According to the CREG, natural gas price projections have been increased significantly over the short term. The estimated price was increased from $2.85 per thousand cubic feet (mcf) to $3.50 per mcf for calendar year 2000, and from $2.50 per mcf to 4.50 per mcf for calendar year 2001. Calendar year 2002 estimates were anticipated to increase from $2.25 per mcf to $3.00 per mcf. The long-term price estimate was held at $2.25 per mcf over the rest of the forecast period (2006). The average price expected over the FY 2001 period (July 2000 through June 2001) was increased from $2.67 per mcf to $5.00 per mcf. Prices are then expected to moderate, but still remain significantly higher than previously forecasted levels over the relative short term (Wyoming Division of Economic Analysis 2001).

Natural gas production estimates were anticipated to increase slightly by 50 million mcf per year over the forecast period for the State of Wyoming. Coal bed methane production figures were revised from 135 million mcf to 145 million mcf for 2000 production, from 190 million mcf to 175 million mcf for 2001, and from 250 million mcf to 225 million mcf for 2002 (CREG 2001).

CBM production under the Proposed Action would be generated by the 12,077 wells approved or constructed before 2002 and the 39,697 CBM wells drilled from 2002 through 2011. The revenue generated from the existing wells has already begun and those revenues are addressed in the cumulative effects. The assessed sales value from new CBM and new conventional wells are described below.

In January 2001, CREG estimated a natural gas price of $2.25 per mcf for the period 2001 to 2006 (Wyoming Division of Economic Analysis 2001). This price also was assumed for this analysis. Assuming each CBM well produces 400 million mcf (DeBruin, Lyman, Jones and Cook 2001), each well would generate an estimated $900,000 (constant 2001 dollars) total sales value. Using $2.25 per mcf, Alternative 1 is expected to contribute a sales value of nearly $35.4 billion (constant 2001 dollars) over the life of the Project to the local, State, regional, and national economies.

Non-CBM (conventional oil and gas) under the Proposed Action would be generated by 3,200 conventional wells drilled by the end of 2011. The analysis assumed the conventional wells produce 80 percent oil and 20 percent natural gas (Crockett 2001). Also, for the purposes of this analysis, a $25.25 per barrel of equivalent (BOE) over the life of the Project was assumed based on CREG estimates between 2001 and 2006). The assumed production rate of conventional wells, which average 137,500 BOE (Crocket 2001), for the their 15 year produc-

tive life (BLM 2001) was also used for the purposed of this analysis. Using these estimates, over its productive life, each conventional well would generate an estimated $3.5 million (constant 2001 dollars) total sales value. The total sales value of conventional wells would be approximately $5.5 billion (assuming a 50 percent success rate), of which $4.4 billion would be from oil production and $1.1 billion would be from natural gas over the life of the Project.

Overall, assuming 100 percent success rate, CBM well development would contribute sales valued at nearly $35.4 billion (constant 2001 dollars) over the life of the Project to the State, regional, and national economies and assuming 50 percent success rate, non-CBM would contribute sales value at nearly $5.5 billion. The total sales value resulting from these success rates would be $40.9 billion in sales value. These values do not account for the sales value from the associated facilities or equipment and supplies associated with the facilities for CBM and non-CBM wells, which would contribute to an even higher sales value and thus increase the tax revenue within the Project Area.

Population

Oil and gas operations play an important direct and indirect role in the local economy through jobs that are created in the community. Additional jobs result in additional personal income, and improved and or additional community needs, such as schools, utilities, and transportation systems.

The Project is not expected to result in significant short- or long-term effects to local population conditions. It is assumed that most of new full-time workers would be recruited from communities within the Project Area and that construction employment and contractors would be available in the region (Keanini 2001a).

Substantial CBM exploration and development activities are currently ongoing in the counties. To the extent that additional non-local contractors or permanent employees are needed, they may relocate to the area for a limited period of time (2 to 5 years) during the major construction phase of the Project (Keanini 2001b). Therefore, it is expected that only a small to moderate increase in population growth would occur.

It is not anticipated that this Project employment would substantially affect demographic characteristics of any of the counties in the Project Area.

Direct and Indirect Employment

Implementation of Proposed Action would have a substantial effect if it resulted in a negative change in local economic conditions or wages, resulted in a short- or long-term reduction in employment, or created the potential for a boom/bust employment cycle. Development of the Project would be completed in approximately ten years from project initiation. The overall production lifetime of the wells is expected to be in the range of 7 years. This includes the 12,077 CBM wells already permitted in the Project Area, in addition to the 39,367 CBM wells and 3,200 non-CBM wells proposed. Both direct Project employment (e.g. positions with one of the Companies or contractors hired for construction, production, and decommissioning) and indirect or secondary employment (jobs that be-

come available in support industries as a result of Project activities, such as parts and materials production, equipment refueling, etc.) would arise as a result of project activities.

Direct Employment

Implementation of the Project would create some additional employment opportunities in the Campbell, Converse, Johnson, and Sheridan counties; however, it is anticipated that most of the jobs would be hired from the local labor force (Keanini 2001a). It is speculative to determine as to which counties within the Project Area these employees will live and work, and therefore this was not evaluated for this analysis. Table 2–16 identifies estimated employment requirements for the Proposed Action associated with CBM and the following text identifies employment needs for non-CBM activity and additional facilities required. Non-CBM estimates are based on wells and roads projected; however, it is assumed that adequate workers required for non-CBM compressor, pipeline, and utility lines construction are accounted for in the CBM facility estimation. Due to the long-term nature of the Project, coupled with fluctuation in natural gas economics and the Companies involved in the leases, developing exact projections of employment is difficult. Therefore, the following paragraphs provide a reasonable estimate of what employment effects can likely be expected with project implementation.

Construction and Installation

The primary influx of employment opportunities associated with the Project is expected to occur in the first ten years of the Project, during the development phase. During this phase, the primary activities would be well drilling and completion and construction of associated ancillary facilities (e.g., access roads, pipelines, power lines, and compressor stations). As shown in Table 2–16, it is anticipated that these activities would require 1001 workers per day. After the initial 10-year development period, rigs would drill replacement wells for those depleted plugged and abandoned, or for isolated filed development. Non-CBM development would require approximately 42 workers per day for the life of the Project.

Employment opportunities are expected to be the greatest over the first ten years (the construction phase) and then constant over the remaining life of the Project. Employees and contractors would be hired or reassigned because, for the most part, they already work in the area to construct and maintain roads and well pads, construct utility trenches, and install underground gas pipelines, water pipelines, and utility lines. Local contractor jobs would include gravel and water truck drivers, heavy equipment operators, and pipeline workers, comprised primarily of workers currently located within the Project Area.

Some components of the Project's workforce would be non-local transient construction workers with specialized expertise required to drill and complete wells. It is assumed that these workers would reside in the Project Area for about six months each year (May through November) during the construction season. It is assumed that the majority of these workers would reside in motels while they are working in the area and would not bring families with them. Many of these con-

tractors would leave the Project Area once the construction and development phase of the Project is finished.

Necessary skills would include: pump and pipeline maintenance, compressor and electric motor maintenance, and production monitoring. Many of these positions would likely be filled by workers currently underemployed in service or trade sector jobs. Some jobs that require a higher or different level of expertise may be filled by non-local workers.

Operation /Maintenance and Decommissioning

Once the CBM wells have been installed some level of sustained permanent employment (as described in Table 2–16) would be related to maintenance and operation of the fields over a 20 year period. Additionally, gradual reclamation of the inactive wells, and associated access roads would be an on going effort in the later years of the Project. Fewer workers would be required to perform these functions. Approximately 378 CBM workers and approximately 17 non-CBM workers would be required for the operation and maintenance phase, and the majority of these workers would be pumpers. Implementation of remote monitoring is anticipated to decrease the number of workers traditionally required for operation and maintenance.

The final stage of the Project life cycle involves the reclamation and abandonment of facilities, which may also trigger 595 jobs for CBM and approximately 8 jobs for non-CBM wells for a period of ten years, during which the various facilities would be dismantled and removed or abandoned in place and surface areas are reclaimed.

As a result of the Proposed Action, at a minimum it is assumed that 2,041 employees would be required for the life of the 20-year Project, consisting of annual employment of 1,974 CBM workers, 67 non-CBM workers. It is assumed, that due to the revolving nature of CBM, these employees already live in the area and would be available for work (Keanini 2001a).

Indirect Employment

In addition to the CBM and non-CBM related jobs to the local economy, during the life of the Project purchases and expenditures made by Project employees within and outside of the affected counties, which would in turn extend the length of time of secondary jobs for the life of the Project. However, because most of these jobs have been filled by employees living in the area, it is anticipated that few secondary jobs would be created, but may sustain for a longer period of time than previously anticipated. Since the vast majority of service and retail trade activity occurs in the Gillette, Wright, Buffalo, and Sheridan communities, it is assumed that most of these jobs would be created in these or nearby communities in Project Area.

Wages

The Project also would contribute to the local economy through the generation of earnings that would be spent on items such as housing, food, goods and services. In addition, economic benefits would occur as a result of the Companies spending on purchases of equipment and supplies from local area vendors.

The wages and salaries paid to long-term Project employees would contribute and estimated total annual personal income to the local economy of $81.6 million (in constant, 2001 dollars) per year, using an average annual income of $40,000 (Powder River CBM Information Council 2001). Over a 20 period, these local jobs created by the stimulation of the economy would contribute an additional $1.6 billion. The average annual income would primarily be contributed to the affected counties.

As the Project life expectancy nears completion, additional costs and expenditures would occur as wells are plugged and decommissioned. Projections of these costs are unavailable at this time. Both expansion of existing businesses and creation of new business can be anticipated due to the increase of longevity of existing jobs. However, once the development phase of the Project is completed, a reduction in service and trade sector employment can be anticipated. Some additional earning from the indirect employment also can be expected and these earnings would be spent in, and contribute to, the local economy. Once the development phase of the Project is completed, indirect earnings from secondary employment would eventually be reduced.

Local Economy and Potential for Boom/Bust Cycle

Implementation of the Project would create both primary and secondary employment opportunities, contribute to the local economy, and provide a substantial source of revenues for local agencies through the collection of royalty taxes. If current estimates and plans are realized by each of the Companies involved in the Project, it is assumed employment opportunities would occur primarily in the first 10 years of the Project, while revenues may extend for as long as 20 to 30 years when Project activities and gas production would slow or cease and so would the associated economic benefits. Some concern was expressed during scoping related to the potential of Project activities to create a boom/bust economic cycle similar to what was experienced in the area in the early 1980s.

The potential for the Project to result in a substantial economic boom/bust cycle is low. If anything, by adding wells to an area that may already be subject to slight Boom/Bust cycle activity, the Project would likely extend the locally strong economy longer than previously anticipated. While this Project would increase the importance of these sectors in the local economy, when compared to the overall economy these activities represent a relatively small share of the economy. Project activities are expected to begin and end in a gradual fashion, and a major lay-off or royalty reduction is not anticipated. Historically, the economies of counties with in the Project Area have been subject to the fluctuations associated with resource extraction and are probably less sensitive to this phenomenon than other areas. In addition, there are a number of other ongoing economic activities and concerted efforts by local authorities to diversify the local economy. These factors all lead to the conclusion that while the conclusion of Project activities would create a gap in employment and the economy, it is not expected that this gap would equate to the overall collapse of the region or a significant localized depression cycle. Although there is a risk for the oil and gas industry and potential for some risk to the local economies, there would be no risk to the overall economy of the Project Area.

Housing

To the extent that Project-created employment results in a concentrated housing demand or shortage, either short or long term, the effect of the Proposed Action would be considered significant. Effects shall be measured on both a local and regional level. If transient housing, e.g. man camps or motel rooms, would be required for short-term accommodations for construction or other laborers that are currently not available, the effect is deemed significant.

Minor employment or population changes are anticipated as a direct result of implementation of the Proposed Action. The increase in population would be small relative to the total population. Because most employees are expected to be hired locally, the demand for additional temporary or permanent housing within the near the Project Area likely may be met with the existing housing supply, depending on the vacancy rates during the period of operations. The majority of available housing units in the Project Area are located in the communities of Gillette, Wright, Sheridan, and Buffalo and it is anticipated that the majority of employees would live in Campbell County. Construction-phase workers who migrate into the area may reside in rental units within these communities. The rental vacancy rate for 2000 in the Project Area was 9.5 percent, only 0.2 percent lower than the State of Wyoming rental vacancy rate of 9.7 (Wyoming Division of Economic Analysis 2001c). There would likely be sufficient existing rental units to house the in-migrant portions of the workforce. Additional rental units may be constructed if the existing supply of vacant rental units becomes exhausted.

Community Facilities and Services

Roads, Water and Wastewater Systems, and Solid Waste Disposal

Access to portions of the Project Area from State and Federal highways would require the use of certain county roads. Project activities could potentially result in increased traffic and use of roads, including additional wear and tear from heavy vehicles. The increased use of county roads may increase maintenance costs to county special districts. Both paved and non-paved roads may be affected. The Project's effects on roads are described in the Transportation section of Chapter 4 starting on page 4–243.

Water would be required for construction and operation of the Project. Total water requirements would equal 6,896 acre-feet/year. The Companies would purchase water locally from a variety of sources, resulting in very minor shifts in water consumption from existing uses to this Project.

Because there is only a small population increase and subsequent housing demand expected with Project implementation, a significant effect on domestic water service provision (in terms of supply and conveyance systems) is not expected. In addition, neither the Project itself nor subsequent development resulting from Project employment (if any) is expected to have any effect on local wastewater facilities. Certain wastes would be disposed of onsite or recycled and other waste products would be disposed of at the local landfill. It is not anticipated that the addition of this waste stream would substantially affect the local landfills or their capacities.

Public Schools, Law Enforcement, Fire Protection, and Medical Facilities

Public schools in the region are not anticipated to experience significant increases in student enrollment as a result of the Project. Due to the limited population increases expected and the long-term time frame associated with the Project, public schools are not anticipated to experience the potential effects of substantial growth resulting from the Project. If current plans change, resulting in a significant number of Project workers being recruited from outside the local area who bring school-aged children with them, existing over-crowded conditions may be exacerbated.

Given that the population growth is expected to be consistent with typical growth rates, law enforcement, fire protection services, and medical are not expected to experience substantial effects as a result of Project implementation.

Public Finance

The Project would be considered to have a significant effect on public finance if local government fiscal conditions were impacted in such a way that revenues would not adequately provide public facilities and services at established levels.

Implementation of the Proposed Action would result in some level of both costs and benefits for the counties in the Project Area. Regarding financial costs, the primary Project-related impact is related to the use of county roads. Revenues used by these counties are generated through Federal mineral lease royalties, State payments in lieu of taxes, and interest earned on unanticipated funds. Additional Project-related costs to the counties may arise from administrative services. Examples of these costs include mapping, naming, and signing of new roads developed in the Project Area for emergency access, as well as other staff and administrative costs.

Mineral Royalties

The Mineral Management Service, U.S. Department of the Interior collects mineral lease royalties, for gas produced by wells completed on Federal lands. Federal royalties would be paid for each well producing from Federally owned oil and gas mineral estate. After administrative costs are deducted, half of the royalties would be retained by the Federal government, and used for the General Fund and various other funds. The remaining half would be distributed to the State of Wyoming, and used for schools, roads and other public works. For the purpose of this analysis royalties are estimated as percentage of the total Project yield for each well multiplied by the market price for the product.

It is estimated that about 39,367 CBM wells and 3,200 conventional wells would be completed on Federal, State and fee (private) minerals in the Project Area through the end of the estimated Project life. Substantial revenues would be generated through these mineral royalty payments. For this analysis, all Federal revenues are assumed to be a result of mineral royalties. It is assumed that revenue from leases and lease bonuses are not a part of this analysis.

Federal Royalties

For the purpose of analysis, federal royalties as a result of CBM activity have been estimate as $112,500 per federal well (using 12.5 percent of the estimated sales value of $900,000 for each well). Of the 39,367 CBM wells, up to 23,909 are expected to be CBM wells with federal minerals. The Project is expected to generate estimated federal royalties of $2.7 billion (constant 2001 dollars) from CBM wells over the life of the Project. One half of this total would be distributed to the federal government and the remaining half would go the State of Wyoming based on equivalent royalty rate.

For conventional wells, federal royalties have been estimated as $437,500 per federal well (using 12.5 percent of the estimated sales value of $3.5 million for each well). Of the 3,200 conventional oil and gas wells, up to 1,855 are expected to be federal wells. Assuming 50 percent success, the Project is expected to generate federal royalties of an estimated $406 million (in constant 2001 dollars) from conventional wells over the life of the Project. Approximately half of this total would be distributed to the federal government and the remaining half would go the State of Wyoming.

Overall, the Proposed action would result in approximately $3.1 billion in Federal royalties.

State Royalties

State royalties would be paid for each well producing from state-owned oil and gas mineral estate. State surface does not always correlate with state minerals, however, for the purpose of this analysis, state mineral data was calculated using state surface with non-federal minerals, due to the lack of available state mineral ownership for the entire Project Area. Using this assumption, there are 2,668 CBM wells on state minerals. For the purpose of this analysis, State of Wyoming royalties have been estimated as $150,030 per state well (using 16.67 percent of the estimated sales volume of $900,000 for each well). The Project is expected to generate approximately $400 million (constant 2001 dollars) in state royalties over the life of the Project. State royalties are placed in the permanent fund and used for schools and public institutions.

Using the assumptions above for State minerals, there are 214 conventional wells on State minerals. For the purpose of this analysis, State of Wyoming royalties have been estimated as $580,000 per state conventional well (using 16.67 percent of the estimated sales volume of $3.5 million BOE for each well). Assuming a 50 percent success rate, the Project is expected to generate approximately $62 million (in constant 2001 dollars) in state royalties from non-CBM over the life of the Project. State royalties are placed in the permanent fund and used for schools and public institutions.

Overall, the Proposed Action would result in approximately $462 million in state royalties.

Fee Royalties as a result of CBM and conventional well development

Fee royalties would be paid in royalty owner(s) of each well producing from the privately-owned mineral estate. The amounts paid, as fee royalties are not avail-

able to BLM. State and county governments do not receive royalties generated from the private mineral lands, but do collect severance and ad valorem taxes, and sales and uses taxes.

Sales and Use Tax Revenues

The Proposed Action would contribute to revenues of the State of Wyoming and its counties through sales and use taxes from the purchase and use of tangible goods. The State of Wyoming collects a four percent sales and use tax for each well, and the counties each collect one percent per well, for a total and use tax of five percent (BLM 1999). State taxes are retained by the State, and are partially disturbed to county and municipal governments. County sales and use taxes are distrusted primarily to the counties imposing the tax.

Sales and use taxes for oil and gas operations are applied to the following categories of tangible goods and services that are purchased or used during the CBM development: 1) coring or sampling; 2) well logging; 3) formation testing; 4) plugging and abandonment: 5) production casing: and 6) well completion. Generally those services directly related to drilling are not taxable. Well maintenance and repair services are taxable. Purchases of separate lines, tanks, and other units used in the collection, processing or transportation of oil and gas are taxable.

The taxable value per CBM well is estimated to be $36,000. This figure was calculated by applying an estimated factor of 60 percent (taxable goods and services) to a total drilling and completion CBM well cost of $60,000 (Western 2001). There would be 39,367 CBM wells resulting in $70.8 million in taxable drilling costs. For the purposes of this analysis non-CBM wells would be assumed to have similar sales and tax revenue per well, which would contribute an addition $5.8 million in taxable drilling costs. All of these expenditures are subject to sales revenue and tax, totaling $76.6 million paid to the State and the counties over the period of time that taxable goods and services are purchased (life of the Project).

Additional sales tax revenues will also be generated from the cost of the other water handling facilities. The sales tax over the life of the Project from water handling are shown in Table 4–104. Because sales taxes are based on tangible goods and the design of the water handling methods are on a conceptual level, tangible goods were based on estimates and assumptions. These costs are incomplete and are only presented to be used as a comparative analysis. The total sales tax revenue generated from water handling of this alternative is estimated to be $73.94 million for the life of the project.

Overall, CBM and non-CBM activity in the Proposed Action would result in approximately $150 million in sales tax returned to the State and counties, over the life of the Project.

For CBM wells, severance taxes on fee wells are calculated at a six percent rate for the State of Wyoming. Based on a sales value of $900,000 per well, the severance tax over the life of the Project is expected to be $ 54,000 per well. As a result, the 39,367 wells, would generate $2.1 billion in severance tax over the life of the Project paid to the State of Wyoming. Assuming a 50 percent success rate,

the 3,200 non-CBM wells will generate $333 million in severance tax over the life of the Project paid to the State of Wyoming

Table 4–104 Water Handling Sales Tax Revenue

Type of water handing facility	Sales tax generated from water handling facility (millions)
Surface discharge (includes untreated, active treatment, passive treatment)	$29.0
Infiltration	$32.0
Containment[1]	$6.80
LAD	$1.01
Injection	$5.13
Total	$73.94

Note:
1. O&M unknown and therefore not included.
Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

Over all, CBM and non-CBM wells in the Proposed Action would result in approximately $2.4 billion in severance tax distributed to the State of Wyoming.

Local Ad Valorem Tax Revenue

Additional project revenues would be generated throughout the collection of an ad valorem/property tax levied on improvements constructed by the Companies. Since this tax assessment is based on value added to property, revenues would increase based upon the number and location of wells. No estimate of the assessment of improvements associated with well development was available, however, assessed value would be determined as a percentage of the actual cost of the facilities (BLM 1998). Theoretically, revenues would gradually increase over the first ten years in all four counties, provided a steady revenue stream for a period of years, and then decline as facilities are dismantled and reclaimed. These projections are subject to the number, locations, and life span of facilities and gas production.

County ad valorem tax rates for Campbell, Converse, Johnson, and Sheridan Counties vary slightly. In Campbell and Converse Counties the tax rate is 6.3 percent and in Johnson and Sheridan Counties the tax rate is 6.8 percent (BLM 2001). As shown in Table 4–105, Campbell County is estimated to receive $1.5 billion (constant 2001 dollars) in ad valorem taxes from CBM and non-CBM wells, the highest of the four counties in the Project Area. Johnson County is estimated to receive $690 million in ad valorem taxes from CBM and non-CBM wells, the second highest amount of the four counties in the Project Area. Sheridan County is estimated to receive $443 million in ad valorem taxes form CBM and non-CBM wells and Converse County is estimated to receiver 32 million in ad valorem taxes form CBM and non-CBM wells.

Table 4–105 Ad Valorem Taxes by County

	Wells Proposed	Ad Valorem Rate (percent)	Sales Value of the Well (dollars)	Net Ad Valorem (dollars)
CBM				
Campbell	21,300	6.3	900,000	1.2 billion
Converse	176	6.3	900,000	10 million
Johnson	10,780	6.8	900,000	660 million
Sheridan	7,111	6.8	900,000	435 million
Total				2.3 billion
Non-CBM[1]				
Campbell	1,339	6.3	3.5 million	295 million
Converse	100	6.3	3.5 million	22 million
Johnson	126	6.8	3.5 million	30 million
Sheridan	35	6.8	3.5 million	8.3 million
Total				355.3 million
Grand Total				2.7 billion

Note:
1. Assumes 50 percent success rate.
Source: BLM 2001c

Over all, CBM and non-CBM wells in the Proposed Action would result in approximately $2.7 billion in ad valorem taxes for the four counties within the Project Area that is used by the county governments to fund vital programs like public schools, hospitals, libraries and special districts, including conservation districts (Powder River CBM Information Council 2001).

Based on these assumptions, it is estimated that sales and use tax, severance tax and ad valorem tax revenues generated over the life of the Project would approximately be $5.2 billion ($2.7 billion ad valorem, $2.4 billion severance, and $150 million sales tax), which would represent a significant impact to the State and local economies.

Quality of Life

Project-related changes in existing ways of life that cause community discontent sufficient to raise conflict and organized response/opposition would be considered to represent a significant impact on quality of life. The perception of a "quality of life" is a very subjective and personal idea, which varies significantly by individual, location, and interests. Quality-of-life issues were raised as part of scoping for this Project; however, little or no information regarding a definition of this issue was provided by respondents. It is clear that no one would be in favor of a "poor" quality of life, but it is difficult to assess what specific aspects of a long-term project may cause an individual's perception of quality of life to change in a negative manner. Additionally, many of the factors that would be considered by most to improve a quality of life (e.g., employment opportunities, municipal services, and vital economy) may or may not be achievable without some increase in factors seen to mar a quality-of-life perception (e.g., traffic increase, visual impairment, use of Federal lands for resource extraction, or influx of transient workers). Each of these factors is discussed in the following paragraphs.

Local Economy

Over time, the Project would result in effects that would be considered to both aid and deter from a common perception of a desirable quality of life. All of the social and economic topics described in this section would factor into a "quality of life". It has been concluded that over the 20-year expected life span of the Project, increased employment in certain sectors would be realized. These opportunities (primarily within the first five years of Project development) would require skilled as well as unskilled labor. Many of these jobs could be filled by workers with similar skills who are currently residing in the Project Area. Employment opportunities and economic stability are a positive factor in the quality of life.

Visual Effects

Project development would noticeably increase activities on Federal lands throughout the Project Area. During the ten-year development phase, it is expected that there would be numerous ongoing drilling operations that would increase noise and dust and pose local visual impairment. Once wells are completed, well pad and pumping units would dot the landscape in certain areas. New road and pipeline corridors also would be noticeable. These effects are a necessary part of resource extraction activities in the area. These features may affect one's perception of quality of life in terms of a visual impact experienced primarily during outdoor recreational activities in the Project Area. Localized visual effects, while unavoidable with Project implementation, can be lessened by some extent through mitigation, such as screening and painting.

Traffic Congestion

Implementation of the Project would result in an increase in traffic on Federal, State, and local roads. Truck and heavy equipment traffic on Federal lands, State highways, and county roads would increase. Some additional traffic on local community roads also may occur over time as new employees and Project activities create additional trips. The major traffic congestion would occur at locations along I-25, I-90 and SH-59 where vehicles and construction equipment would enter and exit the Project Area.

Climate and Air Quality

Climate and air quality are generally perceived as a factor in a definition of quality of life. The Proposed Action would have no effect on the regional climate. Furthermore, implementation of the Proposed Action is not anticipated to have significant effects to regional air quality. Since there are no changes to climate or significant effects or degradation to air quality anticipated, neither of these factors would affect quality of life.

Community Facilities and Services, Community Values

As described in previous sections, the Project would generate revenues currently not available to Campbell, Converse, Johnson, and Sheridan Counties. These revenues would likely be used for a variety of purposes, including funding for additional community facilities and services. While there may be a moderate increase in demand on existing services over time as Project activities proceed, these affects have not been determined to be significant. Careful planning and budgeting of revenue would allow municipalities to consider such things as

school additions, parks, recreational facilities, additional law enforcement officers, and other services and facilities.

It would be highly speculative and very difficult to predict the Project's long-term impact on community values. Likewise, it would be difficult to assess whether or not implementation of the Project would have any effect on religion associated facilities in the area.

Crime

There is no information available that links natural gas development to increases in crime in a particular area. It would be impossible to predict increases or decreases in rates of crime resulting directly from Project implementation.

Property Values

Property values increase as result of high demand property and low supply. Property within the Project Area have increased in recent months, primarily due to the influx of population, CBM and non-CBM related, and the value of land due to royalties associated with CBM activity. Property values may also be affected negatively by the presence of CBM activity and associated activity (visual, traffic, etc). It would be highly speculative to quantify these effects positively and negatively given the size of the Project Area and the social factors related to property values.

Environmental Justice

This socioeconomic analysis provided a consideration of effects with regard to disproportionately adverse effects on minority and/or low-income groups, including Native Americans. No potentially adverse effects that disproportionately affect Native American tribes or minority and or low-income groups have been identified. Issues related to the social, cultural, and economic well-being, and health of minorities and low income groups (environmental justice) issues were evaluated during the analysis of the Proposed Action on socioeconomic resources, surface water and ground water quality, air quality, hazardous materials, and other elements of the human environment. No environmental issues were identified.

Implementing the Proposed Action would not have significant adverse affects on the social, cultural, and economic well being, and health of minorities and low-income groups. With regard to environmental justice issues affecting Native American tribes or groups, the PRB CBM Project Area does not contain tribal lands or Indian communities, and no treaty rights or Indian trust resources are know to exist for this area. There are no communities within the Project Area that would be likely to be physically impacted by the reasonably foreseeable development of CBM. Communities outside the Project Area, which would have a low potential to be affected from a water quality perspective, include the Northern Cheyenne and Crow Reservations in southern Montana, just north of the Upper Tongue River Watershed. It is not anticipated that there is a high potential for water quality degradation flowing into the reservations; however, water quality agreements and measures are discussed below with respect to environmental justice.

The Tongue River flows directly into the Northern Cheyenne and Crow Reservations. As stated Chapter 2, the Companies are required to monitor and report produced water volumes and quality to WDEQ pursuant to NPDES permit requirements. Discharges are required to meet all applicable WDEQ-WQD water quality standards and regulations at all times. The Companies on a voluntary basis have also initiated and funded several studies that are intended to address the cumulative effects of the collective water discharges. Additionally, WDEQ and MDEQ have initiated the Montana and Wyoming Powder River Interim Water Quality Criteria Memorandum of Cooperation (MOC). The intent of the MOC, with respect to environmental justice, is to recognize a responsibility and an opportunity to collaboratively protect water quality in the Powder River Basin to facilitate the development of CBM activities in the respective states. Under the MOC, the State of Wyoming recognizes Montana's downstream interests and has committed to apply certain limits on the development o CBM activities, during the term of the cooperative effort and would work with and support Montana's efforts to develop long-term water quality standards and an equitable allocation of the assimilative capacity if one exists.

Alternative 2

Alternative 2 specifically relates to methods for handling produce water may slightly increase the land required to dispose of water. Such increase in land use may have negative visual implications ultimately affecting the "quality of life".

Alternative 2A and 2B result in minimal change to the employment, wages, housing, infrastructure and royalties. Because of the water handling methods emphasized in these alternatives, CBM employment will increase to 2,260 for 2A and 2,112 for 2B, primarily resulting in the construction of these facilities. Non-CBM employment will be the same as Alternative 1. Therefore, an additional $1.86 billion (2A) to $1.73 billion (2B) in annual wages over the life of the Project will be generated as a result of the additional employment from the water handling facilities. There may be a slight increase in infrastructure demands, however there will be an increase in traffic as a result of the water handling methods. The number of wells remain unchanged, therefore royalties are the same as the Proposed Action. Of all the socioeconomic issues, taxes will be the most affected, due to the cost of the water handling facilities. Specifically, sales tax revenues will be altered. Water handling as it applies to the cost of each method and number of each method is described below.

Alternative 2A Water Handling

Tax revenue generated from Alternative 2A may be slightly higher than that of the Proposed Action primarily due to the number and types and amount of water handling methods. The primary water handling cost of Alternative 2A is a result of emphasis of infiltration water handling. As shown in Table 4–106, the total sales revenue generated from the water handling portion of this alternative is estimated to be $94.4 million for the life of the project.

Table 4–106 Alternative 2A – Water Handling Sales Tax Revenue

Type of Water Handling Facility	Sales Tax Generated From Water Handling Facility (millions of dollars)
Surface Discharge	10.8
Infiltration	66.8
Containment[1]	7.90
LAD	3.44
Injection	5.52
Total	94.4

Note:
1. Operation and maintenance costs are unknown and not included.
Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

The total sales tax generated from drilling and water handling in Alternative 2A is estimated to be $171 million for the life of the project.

Alternative 2B Water Handling

Tax revenue generated from Alternative 2B is slightly higher than the Proposed Action, and Alternative 2A due to number of surface discharge and infiltration water handling methods. As shown in Table 4–107 the total sales tax revenue generated from water handling of this alternative is estimated to be $100 million for the life of the Project.

Table 4–107 Alternative 2B — Water Handling Sales Tax Revenue

Type of water handing facility	Sales Tax Generated from Water Handling Facility (millions of dollars)
Surface discharge	35.8
Infiltration	48.0
Containment[1]	7.2
LAD	3.44
Injection	5.52
Total	99.96

Note:
1. Operation and maintenance costs are unknown and not included.
Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

The total sales tax generated from the drilling and water handling of Alternative 2B is estimated to be $177 million for the life of the Project.

The two compression options for these alternatives include electrification of 50 percent of the booster compressors, with the difference using gas-fired booster compression and electrification of 100 percent of the booster compressors. The cost associated with these alternatives varies depending on the price of gas versus the price of electricity. For the purpose of this analysis, if the price of electricity is assumed to be $0.0372/kilowatt hour (KWH)(Browne 2001) and a fully loaded

engine can produce the equivalent of .746 kilowatt hours (kWh), then electric generation would cost approximately $0.02775 per horse power hour (hrsp-hr).

Assuming the gas-fired engine requires .01 mcf per hspr-hour (Zavadil 2001) and gas is at $2.25 per mcf (Wyoming Division of Economic Analysis, 2001), gas-fired compression would cost approximately $0.02250 per hrsp-hr. Therefore, the price of gas would represent approximately a 19 percent savings. Additionally, because the gas is used on these compressor engines, there is some savings from the basis differential, gathering and compression rates, transport deductions, and royalty and ad valorem savings, which ultimately result in lower net fuel cost. For instance, the fuel cost might be $3.00/mmbtu, however after these deductions, the true cost for fuel is only $1.32/mmbtu (Keanini 2001b).

For the purpose of this analysis, given the current projected price of natural gas and electric, natural gas booster compressor units would be more economical to the operators. Electric booster compression units add no economic value to the operators or the community.

Alternative 3 — No Action

Under the No Action Alternative, additional natural gas drilling would not be authorized on Federal leases within the Project Area. However, drilling could still occur on State and private land. The No Action Alternative would result in approximately 637 fewer jobs created in the Project Area over the life of the Project and therefore approximately $510 million in annual income within the counties of the Project Area.

Expenditures made by the Companies and local tax revenues would be reduced substantially because 23,909 fewer CBM wells and 214 non-CBM wells would be drilled under this alternative, which also decreases the revenue generated from other facilities as well. In addition, the costs and benefits of the Project directed to Campbell, Converse, Johnson, and Sheridan counties would be reduced relative to the Proposed Action and Alternative 2. Federal mineral royalties from CBM alone would result in $3.1 billion less in sales value than in the Proposed Action. With no additional federal wells, there would be no additional Federal royalties available and no associated distribution of those royalties to the counties.

Tax revenue generated from Alternative 3 is lower than that of the Proposed Action and Alternative 2a and 2b, primarily due to decreased number of wells activity, which therefore decreases the number of water handling facilities. As shown in Table 4–108, $30.8 million tax will be generated from water handling. The total sales tax generated from drilling and water handling is estimated to be $61.3 million for the life of the project. The severance tax generated from this alternative is estimated to be $1.1 billion for the life of the project. The ad valorem tax generated from this alternative is estimated to be $1.06 billion for the life of the Project.

Additionally, not drilling Federal wells now may result in future negative production rates from Federal minerals. Drilling on private and State minerals would likely result in depletion of Federal minerals, and therefore potential Federal roy-

alties, within portions of the Project Area. Modeling by Joe Meyer, BLM hydrologist, indicated that in an undrilled area within the Project Area, 9 to 22 pounds per square inch (psi) of pressure draw down would occur in as much as 1.5 miles from the boundary of the producing well after 18 months of production (BLM 2001b). Such significant pressure depletion is considered to be large and extensive (BLM 2001b). According to the same report, it is believed that undrilled Federal acreage, specifically within the Upper Belle Fourche River Subwatershed, may have been so severely depleted that an economic well is no longer feasible. It is anticipated, that depletion would continue to worsen and over a wider area within a portion of the Project Area, as CBM development continues (BLM 2001b).

Table 4–108 Alternative 3 – Cost and Sales Tax Revenue

Type of water handing facility	Sales Tax Generated From Water Handling Facility (millions of dollars)
Surface discharge	10.9
Infiltration	14.3
Containment*	2.94
LAD	.5
Injection	2.20
Total	30.8

Note:
1. Operation and maintenance costs are unknown and not included.
Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

Like Alternative 1 and 2, Alternative 3 would not have significant adverse Environmental Justice affects on the social, cultural, and economic well being, and health of minorities and low income groups for the same reasons stated under Alternative 1.

Cumulative Effects

Economic Consequences

The estimated cost of each alternative is provided in Table 4–109. The costs were generated using cost assumptions provided in Table 4–110 and Table 4–111. For the purpose of this analysis, the following costs were not included in this cost analysis: land acquisition and holding; royalties; permitting; engineering; corporate overhead; management; taxes; interest; return of and return on investment; and time value of money. The costs that are estimated were utilized to estimate the socioeconomic impact to the affected communities.

Table 4–109 Estimated Cost of Each Alternative Over the Life of the Project

	Alternative 1 (billions of dollars)	Alternative 2a (billions of dollars)	Alternative 2a (billions of dollars)	Alternative 3 (billions of dollars)
Drilling, Operation and Maintenance, and Reclamation & Decommissioning	9.95	9.95	9.95	3.91
Water handling[1]	2.45	3.15	3.33	1.03
Total	12.4	13.1	13.3	4.94

Note:
1. Water handling includes Surface Discharge (Untreated, Active Treatment and Passive Treatment), Infiltration, Containment, LAD, and Injection.

Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

Table 4–110 Estimated Costs of Drilling and Reclamation for CBM and Non-CBM Wells

Drilling Activities	Estimated cost/ unit (over the life of the project)
Drilling and completion	$60,000 per well[1]
Well Infrastructure Cost per well	$22,000 per well[1]
Additional pd infrastructure	$16,000 per well[1]
Gathering Fees per Mcf	$20,000 per well[1]
Operation and Maintenance	104,000 per well[1]
Reclamation	$700 per acre[2]

Note:
1. Generated using Coal Bed Methane Operators Information Survey Results, prepared for the Eastern Research Group Inc and for the EPA. O&G Environmental Consultants, September 7, 2001.
2. Provided by Williams 2001.

Table 4–111 Estimated Cost of Water Handling Facilities

Water Handling (Includes labor)	Capital Cost of Construction cost per facility	O&M ($/bbl)	Reclamation cost per facility
Surface Discharge	$16,000	$.05[1]	$9,000
Infiltration	$154,000	$.06[1]	$136,000
Containment	$3,600,000	Unknown	$2,523,000
LAD	$500,000[1]	$.02[1]	$3,000
Injection	$90,0000[1]	$.06[1]	$9,000

Note:
1. Generated using Coal Bed Methane Operators Information Survey Results Report, prepared for the Eastern Research Group Inc and for the EPA. O&G Environmental Consultants, September 7, 2001.

Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

The cost was generated using data provided in the Coal Bed Methane Operators Information Survey Results Report, prepared for the Eastern Research Group, Inc. and for the EPA (O & G Environmental Consultants 2001). Additionally, Mike Kolin, P.E., of Greystone, generated estimated Project-related costs. (Kolin 2001). Because the conceptual level of this analysis does not present site-specific design and operation, the cost estimates are incomplete and are only for comparative analyses based upon a series of assumptions. In instances where cost was speculative, it was not included in the analysis (such as roads, pipelines, compressors, electric generation and other well-associated facilities) they were not included in this analysis.

Alternative 1

Although the cumulative economic value of CBM development under this alternative is very large, the cumulative workforce required for the Project is estimated to require approximately 349 employees for the 12,077 approved wells, 1,974 employees for CBM wells and facilities, and 67 employees for the 3,200 non-CBM wells. As a result, the average annual workforce required would be approximately 2,390 employees over the life of the Project. It is anticipated that these jobs filled from the local labor force. The annual payroll from these employees is anticipated to be approximately $95.6 million. Over the life of the Project, the annual payroll is estimated to be $1.9 billion. Employment opportunities will likely be greatest during the first ten years, and would gradually decrease over the life of the Project.

Because the local labor force would likely occupy new jobs, the increased population growth of the communities is not anticipated as a result of the Proposed Action. It is not anticipated that water systems, solid waste disposal, public schools, law enforcement, fire protection, or medical facilities would incur substantial additional effects from the Proposed Action. The local counties are accustomed to absorbing fluctuation in mineral development activities, which cause cycles of increasing and decreasing demands for workers, housing and community services. Much of the infrastructure required for the current population has been created and would sustain the current population.

In addition to salaries generated by the Project, extra revenue would filter to county levels through federal royalties, local ad valorem taxes, and sales and use taxes. Based on projected market prices, it is estimated that federal royalties would total approximately $3.1 billion over the life of the Project. The 12,077 permitted CBM wells are anticipated to generate an additional $151 million, totaling approximately $3.2 billion in federal royalties. Approximately half would be paid to the State of Wyoming and half to the federal government. State mineral royalties, sales and use tax, severance tax and ad valorem taxes would generate approximately $5.6 billion in revenue to be distributed by the State and counties, for schools, roads, and other community infrastructure.

Implementing the Proposed Action would have cumulative effects on social, cultural, and economic well being, and health of minorities and low income groups. With regard to environmental justice issues affecting Native American tribes or groups, the Powder River Basin Oil and Gas Project Area contains no tribal lands or Indian communities, and not treaty rights or Indian trust resources are known

to exist for the area. Environmental effects associated with water quality north of the Project Area on or near the Crow and Northern Cheyenne Reservations will be subject to applicable approved water quality standards by the State of Montana and State of Wyoming.

Alternative 2

Alternative 2 includes all of the cumulative effects as described for the Proposed Action, but differs from the proposed action in water handling and compression. Alternative 2a and 2b would require approximately 287 and 138 additional employees than the Proposed Action.

Alternative 2A results in $21.1 million more sales tax from water handling and Alternative 2B results in $26.7 million more sales tax from water handling than Alternative 1. The use of natural gas fired booster compressors proves to be more economical for the operator and electric booster compressors provide no economic benefit to the community.

Alternative 3

Under this alternative, no additional wells would be drilled on federal lands. Approximately 637 new jobs would be created under Alternative 3 resulting in about $510 million in personal income and $1.1 billion less than under Alternatives 1, 2A, or 2B over the life of the Project. Implementation of Alternative 3 would result in a complete loss of all the federally related benefits and costs described in the Proposed Action because no federal royalties would be collected and the associated distribution of these royalties would not occur. Additionally, not drilling federal wells now may result in future negative production rates on federal minerals, due to depletion of minerals from drilling on state and private lands.

Mitigation

Through the analysis, several potential mitigation measures were identified to avoid, reduce, or minimize adverse effects to various resources. The BLM and FS can require these measures for leases with federal land surface, but can only recommend them for leases with non-federal land surface. These measures, which are in addition to those identified in the ROD for the Wyodak EIS and the Decision Record for the Wyodak Drainage EA, are discussed below by resource area.

Groundwater

1. Concerns exist about the interaction between reservoirs and shallow groundwater. At impoundment locations, it may be necessary to conduct investigation at representative sites around the basin to quantify impacts of water infiltration. This will help determine site-specific guidance on placement and design of CBM related impoundments.

Surface Water

2. Channel crossings by pipelines shall be constructed so that the pipe is buried at least four feet below the channel bottom.
3. Channel crossings by road and pipelines shall be constructed perpendicular to flow. Streams/channels crossed by roads shall have culverts installed at all appropriate locations as specified in the BLM Manual 9112-Bridges and Major Culverts and Manual 9113-Roads. Streams shall be crossed perpendicular to flow, where possible, and all stream crossing structures will be designed to carry the 25-year discharge event or other capacities as directed by the BLM.
4. Disturbed channel beds shall be reshaped to their approximate original configuration.
5. In plan of development areas where natural springs are present, operators shall be required to identify, inventory, and monitor these springs as part of their water management plan development.

Soils

6. The Companies shall submit a proposal for each LAD facility on federal lands for approval before initiating construction of the facility. At a minimum, the proposals shall (1) identify the site-specific chemical and physical characteristics of the soils; (2) provide a detailed operational plan for the facility (e.g., application rates; amendments for water, soils, or both; physical soil manipulations; winter operational plans); (3) include a monitoring plan; and (4) provide a mitigation plan.
7. The Companies shall segregate soil horizons during excavation of all project facilities and avoid mixing of soil horizons during stockpiling and redistribution of soils.

Cultural Resources

8. The Companies shall conduct CBM development in and around the Crazy Woman Battlefield in a way that preserves the eligibility of the site for nomination to the National Register of Historic Places. Approvals of APDs and PODs will require prior coordination with the SHPO and BLM's archaeologists.
9. For development within ½ mile either side of the Bozeman Trail, companies shall conduct evaluation of segments to determine their eligibility to the National Register of Historic Places. Mitigation of adverse impacts to segments of the trail that contributes to its eligibility for the NRHP will be determined on a case-by-case basis.

Air Quality

10. Roads and well locations constructed on soils susceptible to wind erosion shall be appropriately surfaced to reduce the amount of fugitive dust generated by traffic or other activities, and dust inhibitors (i.e., surfacing materials, non-saline dust suppressants, water, etc.) could be used as nec-

essary on unpaved collector, local and resource roads which present a fugitive dust problem. To further reduce fugitive dust, Operators could establish and enforce speed limits (15 – 30 mph) on all project-required roads in and adjacent to the Project Area. In developing the emission inventory for the air quality impact assessment, it was assumed that compressor engines would have an average potential NO_x emission rate of 1.5 g/hp-hr during operation. This reflects an upper emission level anticipated from currently available compressor engines.

11. A variety of potential emission reduction measures (BLM 1999) are available to further limit NO_x and other pollutant emissions. The evaluation was not intended to rank or identify a required emission reduction measure; the appropriate level of control would be determined and required by the applicable air quality regulatory agencies during the preconstruction permit process.

Vegetation

12. Construction equipment would be washed prior to being moved into and out of new work areas in order to remove any noxious weed seeds.
13. Existing infestations of noxious weeds that are within or adjacent to proposed well pads, access roads, or other facilities would be treated prior to construction to minimize the potential for spread of these infestations into newly disturbed areas.

Wetland/Riparian

14. Construction equipment would be washed prior to being moved into and out of new work areas in order to remove any noxious weed seeds.A
15. voidance of impacts to wetland/riparian areas is the preferred mitigation measure. Components of this mitigation measure include: avoidance of discharge in playas or closed basins, avoidance of discharge within or near existing wetland/riparian areas where discharge would result in rising water tables, potentially killing vegetation not adaptable to inundation, particularly cottonwoods and willows, and avoidance of disturbance within all delineated or recognized wetland/riparian areas.
16. To protect the biological and hydrologic features of riparian areas, woody draws, wetlands, and floodplains, all well pads, compressors, and other non-linear facilities shall be located outside of these areas.
17. Crossings of wetland/riparian areas by linear features such as pipeline, roads, and power lines shall be avoided to the extent practicable. Where crossings cannot be avoided, impacts shall be minimized through use of the following measures:
    - Site-specific mitigation plans shall be developed during the APD/POD or Sundry Notice approval process for all proposed disturbance to wetland/riparian areas.
    - Crossings shall be constructed perpendicular to wetland/riparian areas.

- For power lines, the minimum number of poles necessary to cross the area shall be used.
- Wetland areas shall be disturbed only during dry conditions (i.e., during late summer or fall), or when the ground is frozen during the winter.
- No waste material shall be deposited below high water lines in riparian areas, flood plains, or in natural drainage ways.
- The lower edge of soil or other material stockpiles shall be located outside the active floodplain.
- Drilling mud pits shall be located outside of riparian areas, wetlands, and floodplains.
- Disturbed channels shall be re-shaped to their original configuration.
- Reclamation of disturbed wetland/riparian areas shall begin immediately after completion of project activities.

Wildlife

18. The Companies shall conduct clearance surveys for special-concern species at the optimum time. This will require coordination with the BLM before February 1 annually to review the potential for disturbance and to agree upon inventory parameters.
19. For any surface-disturbing activities proposed in sagebrush shrublands, the Companies shall conduct clearance surveys for sage grouse breeding activity during the sage grouse's breeding season before initiating the activities. The surveys must encompass all sagebrush shrublands within ½ mile of the proposed activities.
20. The Companies shall locate compressor stations so noise from the stations at any nearby sage grouse display grounds does not exceed 49 decibels (10 dBA above background noise) at the display ground.
21. The Companies shall locate aboveground power lines, where possible, at least ½ mile from any sage grouse breeding or nesting grounds to prevent raptor predation and sage grouse collision with the conductors. Power poles within ½ mile of any sage grouse breeding ground shall be raptor-proofed to prevent raptors from perching on poles.
22. The Companies shall locate impoundments to avoid sagebrush shrublands, where possible.
23. The Companies shall fence all impoundments in bottom land areas that are developed for fisheries to exclude livestock.

Aquatics Species

24. Ponds developed for fisheries shall be fenced to exclude livestock; water quality in these ponds shall be sampled on an annual basis for selenium, TDS, and sodium bicarbonate, at a minimum.

25. Stream channel monitoring for erosion, degradation, and riparian health shall be conducted on an annual basis. Surveys shall include no less than one stream reach above all CBM discharges and several stream reaches below CBM discharges. Monitoring stations will be placed above all CBM outfalls and below all CBM outfalls, at least on mainstems.
26. Sub-watersheds that will receive CBM produced waters and shall be monitored for macroinvertebrates and fish populations include: Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, Clear Creek, Middle Powder River, Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Sampling sites shall be established at existing flow and water quality monitoring stations where possible. Sampling shall occur on an annual basis during low flow periods, and all data collected shall be entered into a central database. At least two sampling locations per stream or river shall be established in these watersheds:

    - Upper Tongue River – 1) between the Wyoming/Montana border and below all CBM discharge points; and 2) above CBM discharge points.

    - Upper Powder River – 1) above Clear Creek at confluence; 2) above Crazy Woman Creek at confluence; 3) below Salt Creek at confluence; and 4) below other tributaries that may contribute flow to the Upper Powder River.

    - Salt Creek – 1) above Upper Powder River at confluence; and 2) above CBM discharge points.

    - Crazy Woman Creek – 1) above Upper Powder River at confluence; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to Crazy Woman Creek.

    - Clear Creek – 1) above Upper Powder River at confluence; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to Clear Creek.

    - Middle Powder River – 1) between the Wyoming/Montana border and below all CBM discharge points; and 2) below confluence of Upper Powder River and Clear Creek.

    - Little Powder River – 1) between the Wyoming/Montana border and below all CBM discharge points; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to the Little Powder River.

    - Antelope Creek – 1) between eastern Project Area boundary and below all CBM discharge points; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to Antelope Creek.

    - Upper Cheyenne River – 1) between eastern Project Area boundary and below all CBM discharge points; 2) above CBM discharge

points; and 3) below other tributaries that may contribute flow to the Upper Cheyenne River.

- Upper Belle Fourche River – 1) between Campbell/Crook County line and below all CBM discharge points; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to the Upper Belle Fourche River.

- A minimum of 21 sites (as above) would need to be sampled on an annual basis in order to monitor aquatic health within the Project Area.

Threatened, Endangered, or Sensitive Species

27. For any surface-disturbing activities proposed in potentially suitable habitats for the Ute ladies-tresses' orchid, the Companies shall conduct clearance surveys according to the FWS' guidelines (FWS 1992) before initiating the activities. The surveys must encompass all potentially suitable habitats within ½ mile of the proposed activities.
28. The Companies shall conduct clearance surveys for threatened, endangered, or other special-concern species at the optimum time. This will require coordination with the BLM before February 1 annually to review the potential for disturbance and to agree upon inventory parameters.

Transportation

29. The Companies shall use gravel, water, or other dust suppressors, as needed, to reduce dust associated with facility access roads.
30. The Companies shall provide georeferenced spatial data models depicting, wells, roads, pipelines, power lines, reservoirs, discharge points, and other facilities to the BLM semi-annually. The models will depict the as-built locations of all facilities.
31. Companies should enter into maintenance agreements with the counties to ensure the county roads are adequately maintained.

Visual Resources

32. The Companies shall complete the following measures, where possible: use existing well pads where feasible, use vegetative and topographic screening when siting well locations, avoid highwall cuts, and shield drilling rig lights.
33. Within the designated VRM Class II corridors along Interstate 90 and State Highway 14, all project facilities on BLM surface shall be screened completely from these highways.
34. The Companies shall mount lights at compressor stations on a pole or building and direct them downward to illuminate key areas within the facility while minimizing the amount of light projected outside the facility.

Unavoidable Adverse Effects

The sections below describe the unavoidable adverse effects identified during the analysis.

Groundwater and Surface Water

Unavoidable adverse effects to groundwater and surface water would occur. These include the long-term removal of water from the coal aquifers as they are depressurized by the wells. The volume of water in other aquifers would be increased through infiltration and injection. The quality of surface waters would change in response to the discharges of CBM produced water and disturbances of soils and vegetation throughout the Project Area.

Air Quality

Some increase in air pollutant emissions would occur as a result of the development alternatives; however, based on the "reasonable, but conservative" modeling assumptions, these impacts are predicted to be below applicable significance thresholds.

Vegetation

Unavoidable direct and indirect adverse effects would occur under each of the four alternatives. The extent of disturbance would be essentially equivalent for Alternatives 1 and 2, but approximately half the magnitude for Alternative 3. Areas disturbed under each alternative would be subject to a high potential for invasion of noxious weeds and would require substantial effort to prevent and control the spread of these weeds. Restoration of biodiversity in disturbed areas would require an extended period of time and would likely be a function of the spread of native plant species from outside of disturbed areas, a time-consuming process that can be severely delayed by noxious weed invasions. Vegetation types providing crucial wildlife habitats would not likely be replaced for an extended period of time, potentially causing adverse effects to wildlife.

Wetland/Riparian Area

Unavoidable direct and indirect adverse effects would occur under each of the three alternatives. The extent would be essentially equivalent for Alternatives 1 and 2, but approximately half the magnitude for Alternative 3. The primary adverse impact would be alteration of wetland/riparian areas by the discharge of produced CBM water. During production, wetland/riparian areas are likely to expand in size, although increased water flow may also result in increased levels of erosion or sediment deposition, causing adverse impacts. As water production decreases towards the end of the Project, wetland/riparian areas would contract, returning to pre-Project sizes. Areas of excessive erosion or sediment deposition may cease to function as wetland/riparian areas. All of these changes in the extent of wetland/riparian areas would provide opportunities for aggressive species, including noxious weeds, to invade disturbed areas.

Wildlife

Unavoidable direct and indirect adverse effects would occur under each of the four alternatives. The extent of change in water quality, flow, sedimentation, and habitat from discharge of CBM produced waters into surface drainages would be greatest under Alternative 1, followed by Alternative 2B, Alternative 3, and Alternative 2A, respectively. Aquatic species would be affected as mentioned above, and restoration of biodiversity in sub-watersheds affected by CBM produced water discharge would require an extended period of time and would include controlling the spread of exotic species that may occur during the project. Native species may have difficulty recolonizing historical habitats should exotic species invade them, or if populations decline below levels that could sustain population growth.

Threatened, Endangered, or Sensitive Species

Unavoidable direct and indirect adverse effects to special-status wildlife species would occur under each of the four alternatives. These include loss of some foraging and nesting habitats. Unavoidable adverse effects to special-status species of plants could result from construction and vehicular trampling of plants.

Land Uses

For any of the alternatives, there would be unavoidable short-term, adverse indirect effects to the land uses on properties adjacent to the Project-related facilities, resulting from the from noise, traffic, and dust generated by the project-related vehicles and equipment, primarily during the construction-related activities within the Project Area.

Transportation

For any of the alternatives, there would also be unavoidable long-term indirect adverse effects to the properties adjacent to the major access roads within the Project Area due to generation of increased traffic, noise, and dust from the project-related vehicles.

Quality of Life

Effects to quality of life may occur depending on an individual's point of view. For those that prefer the solitude and natural setting, their quality of life would be affected for the life of the Project. Additionally, not drilling Federal wells now may result in future negative production rates on Federal minerals, due to depletion of minerals from drilling on State and private lands.

Irreversible and Irretrievable Effects

An irreversible or irretrievable commitment of resources would occur when resources would be consumed, committed, or lost as a result of the project. The

commitment of resources would be irreversible if the project stated a process (chemical, biological, or physical) that could not be stopped. As a result, the resource or its productivity or its utility would be consumed, committed, or lost forever. Commitment of a resource would be considered irretrievable when the project would directly eliminate the resource, its productivity, or its utility for the life of the project and possibly beyond.

No irreversible or irretrievable effects would occur to air quality, visual or noise resources. The following is a listing of the effects that would occur to the other resources analyzed in this EIS.

Irreversible Effects

- Removal of natural gas
- Transfer of groundwater to surface water

Irretrievable Effects

- Loss of vegetative cover for several years until reclamation is successful
- Loss of riparian vegetation over life of Project
- Loss of portions of big game winter range over life of Project
- Loss of sensitive species habitat
- Loss of livestock forage for several years until reclamation is successful

Chapter 5
Land Use Planning and Management

Chapter 5 — Land Use Planning and Management

The decision-makers for the BLM (Wyoming State Director) and FS (Medicine Bow-Routt National Forests Supervisor) will make several decisions based on the analysis documented in this EIS. First, they will determine whether any changes to current designations of areas open or closed to oil and gas leasing need to occur. Second, they will determine whether current RMP or LRMP lease stipulations are adequate or if new stipulations need to be developed. Third, they will determine if new mitigation measures need to be adopted. Finally, they will determine if any of the management plans need to be amended.

For the BLM, the analyses contained in this EIS will provide the basis for amending the RMPs. The Final EIS and ROD would serve as amendments to the Buffalo and Casper RMP's. For the FS, this analysis and decision would revise previous decisions made by the FS for the TBNG.

Public lands administered by the BLM and FS are generally available for oil and gas leasing, exploration, and development. Decisions to lease oil and gas are an outcome of the analysis and decision of the planning process. Part of that decision is not only what lands will be leased but under what conditions. Conditions under which the lands will be leased are called "stipulations".

Existing federal (BLM and/or FS) oil and gas leases within the Project Area contain various stipulations concerning surface disturbance, surface occupancy, limited surface use, and timing (seasonal) restrictions. These lease stipulations provide for the imposition of such reasonable conditions, not inconsistent with the purposes for which the lease was issued, as the BLM and or FS may require, to protect the surface of the leased lands and the environment. Mitigation measures can be imposed upon a lessee who pursues surface disturbing activities; however, leased land without a "No Surface Occupancy" (NSO) or other similarly restrictive lease stipulation cannot be denied a permit to drill.

Current Status of Management Plans

BLM Land Management

The BLM's principal authority for managing public lands is the Federal Land Policy and Management Act of 1976 (FLPMA, PL 94–579, 43 USC 1701–1782 [Supp.1977]). BLM is responsible for managing public lands based upon the principles of multiple use and sustained yield, compliance with land use plans developed under the Act, and protection of the quality of the resource values. The BFO administers the BLM-administered lands for the portions of Campbell,

Johnson, and Sheridan counties within the Project Area. The BLM CFO administers the BLM lands in the portion of the Project Area within the northern portion of Converse County.

Buffalo Field Office

In 1985, the BFO completed an RMP, which includes land use goals for the BLM-administered public lands and federal mineral estate in the Buffalo Field Office Area (BLM 1985). An updated description of existing management for the Buffalo RMP was completed in April 2001. The update of the 1985 RMP started in 1992 and is based on considerable public input including letters and meetings with individuals and groups. After extensive work with the public the conclusion was that the decisions and management directions from the 1985 Buffalo RMP are still valid (BLM 2001).

Standard lease stipulations and mitigation guidelines for resource protection as provided in "Wyoming BLM Mitigation Guidelines for Surface Disturbing and Disruptive Activities" are now incorporated in the RMP.

Casper Field Office

The Platte River Resource Area RMP was approved in July 1985 and is implemented and monitored by the CFO. With the exception of some specified areas, BLM-administered lands in the Platte River Resource Area are open to oil and gas leasing, subject to the Wyoming BLM mitigation guidelines.

National Forest Land Management

Numerous land parcels within the TBNG are scattered throughout Campbell and Converse counties in the Project Area. Although the Bighorn National Forest is on the western boundary of the Project Area, none of the Bighorn National Forest lands are within the Project Area. Most of the CBM resources on FS lands within the Project Area are located in the westernmost portion of the TBNG. The FS administers the land uses on National Forest System lands based on multiple use principles. The Douglas Ranger District of the Medicine Bow-Routt National Forests administers the public lands and activities within the TBNG. Oil and gas leasing and development activities on National Forest System lands within the TBNG are allowed, subject to the limitations imposed by the LRMP for the Medicine Bow National Forest and TBNG (FS 1985). Actions proposed within the TNBG must conform to the management goals within the LRMP (FS 1985).

No changes to the availability of National Forest Service lands for oil and gas leasing are anticipated. The FS decision as to which lands are currently available for leasing was made in the 1994 ROD for Oil and Gas Leasing. More recently, the Northern Great Plains environmental analysis that is documented in the 2001 FEIS reaffirmed the leasing decision made out of that earlier analysis. Alternative(s) analysis, as required by 36 CFR 228, was conducted during both the 1994 and more recent Northern Great Plains analyses. The Regional Forester needs to

decide from the analysis which lands will be authorized to be offered for lease by the BLM. The FS decision(s) that will be made as a result of this analysis will include lease parcel authorization where that decision has previously been deferred.

The FS completed an FEIS and issued a ROD in 1994 for Oil and Gas Leasing on the TBNG (FS 1994). In 1994, the FS developed many special leasing restrictions for oil and gas activities within the TBNG. Leasing restrictions applicable to drilling or production activities within the TBNG may be included as conditions of approval for APDs on post-1994 leases. The restrictions outlined in the site-specific environmental effects analyses must contain documentation at to whether or not proposed development is consistent with the 1994 FEIS/ROD and the 1985 LRMP.

The Proposed Land and Resource Management Plan for the Thunder Basin National Grassland (Forest Plan) (1999) provides the proposed land use guidelines for the eight management areas within the TBNG. Most of the FS land within the Project Area is managed for livestock grazing. The FS also has special stipulations to protect identified resources within FS-administered lands.

Designation of Areas Open or Closed to Leasing

The decision to not lease oil and gas is made through the planning process. The following sections describe the current status of areas open and closed to leasing.

Current Designations

Buffalo Field Office Area

The only federal oil and gas that will not be leased in the Buffalo Field Office Area are areas within incorporated cites and towns, such as Sheridan, Buffalo, and Gillette, and the three WSAs (BLM 2001a). The rest of the federal minerals in the Buffalo Field Office Area are open to oil and gas leasing. The total acreage for federal oil and gas not leased is 30,200 (Table 5–1).

Casper Field Office Area

No areas closed to leasing exist within the CFO's portion of the Project Area.

Thunder Basin National Grasslands

There are no areas closed to leasing within the Forest Service portion of the Project Area. The decision to make lands available for leasing has already been made in the 1994 ROD for the oil and gas EIS. The analysis in the final EIS for the revision of the TBNG LRMP validates the 1994 decision.

Table 5–1 Distribution of Area Leasing and Stipulations by Federal Management Responsibility within the Project Area

	Buffalo RMP	Casper RMP	TBNG 1985 LRMP	TBNG Proposed 2001 LRMP	Total
Area Closed to leasing					
National Policy Closures (WSAs)	1,333	0	0	0	1,333
Planning Decision Closures (Cities and Towns)	28,867	0	0	0	28,67
Area Open to Oil and Gas Leasing					
Within CBM-productive coals[1]	2,382,929	445,145	95,443	95,443	2,923,517
Outside CBM-productive coals	1,082,583	367,453	161,381	161,381	1,611,417
Area not Leased but Available as of Aug. 2001					
Within CBM-productive coals	119,585	49,153	15,351	15,351	184,089
Outside CBM-productive coals	312,461	16,009	0	0	328,470
Area Leased with Stipulations					
No Surface Occupancy					
Within CBM-productive coals	35,036	8,555	0[2]	32,267[2]	75,858
Outside CBM-productive coals	6,729	4,744			7,203
Controlled Surface Use					
Within CBM-productive coals	84,684	24,444	6,779[2]	654[2]	116,561
Outside CBM-productive coals	14,686	5,755			
Paleontological				213,927[2]	213,927
Timing Limitation					
Within CBM-productive coals	556,952	122,207	31,184[2]	62,994[2]	773,337
Outside CBM-productive coals	135,356	57,196			192,552

Notes:
1. CBM-productive coals are coal beds that are at least 20 feet thick..
2. Forest Service acreage was calculated based on the TBNG plan database.

Because areas may have more than one type of stipulation, the total area with stipulations plus SLT may be larger than the area open for leasing.

Proposed Changes to Designations

Buffalo Field Office Area

None

Casper Field Office Area

None

Thunder Basin National Grassland

None

Oil and Gas Leases and Stipulations

A lease does not convey an unlimited right to explore for or an unlimited right to develop any oil or gas resources found under the land. Leases are subject to terms and conditions. These are restrictions derived from legal statutes and measures to minimize adverse impacts to other resources and are generally characterized in a lease as stipulations. Stipulations modify the rights the government grants to a lessee. The stipulations are known by potential lessees before any sale and must be applied at the time of Application for Permit to Drill.

The Standard Lease Terms (SLT) are contained in Form 3100–11, Offer to Lease and Lease for Oil and Gas, United States Department of the Interior, BLM, June 1988 or later addition. The Standard Lease Terms provide the lessee the right to use the leased land as needed to explore for, drill for, extract, remove, and dispose of oil and gas deposits located under the leased lands. Operations must be conducted in a way that minimizes adverse impacts to the land, air, water, cultural, biological, and visual elements of the environment, as well as other land uses or users.

Federal environmental protection laws, such as the Clean Water Act, Endangered Species Act, and Historic Preservation Act, will be applied to all lands and are included in the standard lease stipulations. If threatened or endangered species, objects of historic, cultural, or scientific value, or substantial unanticipated environmental effects are encountered during construction, all work affecting the resource will stop and the land management agency will be contacted. Surface-disturbing operations that would destroy or harm these species or objects are prohibited. The agencies commonly use Lease Notices to identify the potential for the occurrence of these protected resources, as discussed below.

Standard Lease Terms provide for reasonable measures to minimize adverse impacts to surface resources. These include, but are not limited to, modifications to the siting or design of facilities, timing of operation, and specifications of interim and final reclamation measures. Standard Lease Terms may not require the lessee to relocate drilling rigs or supporting facilities by more than 200 meters (656 feet), require that operations be sited off the leasehold, or prohibit new surface-disturbing operations for more than 60 days each year (43 CFR part 3101.I–2). The lease requires that the lessee meet stipulation conditions or avoid activities within all, or an identified part, of the leasehold. Also, all leases are subject to regulations and formal orders of the Secretaries of the Interior and Agriculture in effect at the time of issuance.

The Standard Lease Terms can be modified by special or supplemental stipulations attached to the lease (43 CFR 3101.I–2 through 3101.I–4). Additional special stipulations can be developed specifically to meet resource concerns that cannot be mitigated by existing stipulations. These special stipulations include:

- *No Surface Occupancy (NSO)* — Neither exploration nor production facilities (e.g., well pads, drilling rigs, and CMFs) would be allowed to be constructed.
- *Controlled Surface Use (CSU)* — Surface occupancy and use are permitted, but are restricted to mitigate effects to particular resources. The CSU

stipulation provides for mitigation measures that would not normally be met by relocating the drilling site the 200 meters provided by the SLT.

- *Timing Limitations (TL)* — Construction activities would be restricted or prohibited during certain periods to protect resources. The TL stipulation provides for mitigation measures that would not normally be met by delaying surface-disturbing operations for the 60 days each year provided by the SLT.

Lease Notices/Special Lease Notices

A Lease Notice (LN) or Special Lease Notice provides information to a lessee concerning resources that are protected by law or regulation thereby making a specific lease stipulation unnecessary. Currently, the BLM applies two LNs to leases in the Powder River Basin. They are Lease Notice No. 1 and a Special Lease Notice for threatened, endangered, candidate, or other special-status species/habitats. Both LNs are described below.

Lease Notice No. 1

The lands within this lease may include areas not specifically addressed by lease stipulations that may contain special values, may be needed for special purposes, or may require special attention to prevent damage to surface and/or other resources. Possible special areas are identified below. Any surface use or occupancy within such special areas will be strictly controlled or, if absolutely necessary, prohibited. Appropriate modifications to imposed restrictions will be made for the maintenance and operation of producing wells.

1. Slopes in excess of 25 percent.

2. Within 500 feet of surface water and/or riparian areas.

3. Construction with frozen material or during periods when the soil material is saturated or when watershed damage is likely to occur.

4. Within 500 feet of Interstate highways and 200 feet of other existing rights-of-way (i.e., U.S. and State highways, roads, railroads, pipelines, powerlines).

5. Within ¼ mile of occupied dwellings.

6. Material sites.

7. Within important scenic areas identified in a land use plan (Class 1 and 2 Visual Resource Management Areas (Platte River RMP).

8. Within ¼ mile or the visual horizon (whichever is closer) of historic trails. This notice applies to all parcels (Platte River RMP).

The intent of this notice is to inform interested parties (potential lessees, permittees, operators) that when one or more of the above conditions exist, surface dis-

turbing activities will be prohibited unless or until the permittee or the designated representative and the surface management agency (SMA) arrive at an acceptable plan for mitigation of anticipated impacts. This negotiation will occur prior to development and become a condition for approval when authorizing the action.

Specific threshold criteria (e.g., 500 feet from water) have been established based upon the best information available. However, geographical areas and time periods of concern must be delineated at the field level (i.e., "surface water and/or riparian areas" may include both intermittent and ephemeral water sources or may be limited to perennial surface water).

The referenced oil and gas leases on these lands are hereby made subject to the stipulation that the exploration or drilling activities will not interfere materially with the use of the area as a materials site/free use permit. At the time operations on the above lands are commenced, notification will be made to the appropriate agency. The name of the appropriate agency may be obtained from the proper BLM Field Office.

Special Lease Notice

Threatened, Endangered, Candidate, or Other Special Status Plant And Animal Species

This Special Lease Notice is applied only for the T&E species that may occur in the Project Area.

The lease area may contain habitats for the threatened, endangered, candidate, or other special-status plant and animal species. Species currently listed are identified below. Additional species may be listed in the future by the FWS. Exploration and development proposals may be limited, or modifications required, if activity is planned within the habitat boundaries of a threatened, endangered, candidate, or other special status plant/animal species as it then exists. Upon receipt of a site specific proposal, the authorized officer will review current inventory records of each location and may require that further localized surveys be performed to assure nc threatened, endangered, candidate (category I or 2), proposed, or other special status species are present. (Endangered Species Act of 1973 as amended, Sections 2 and 7.)

Threatened and Endangered Species

- Black footed ferret - M*ustela nigripes* (Endangered)
- Bald Eagle - *Haliaeetus leucocephalus* (Threatened)
- Ute Ladies'-tresses - S*piranthus diluvialis* (Threatened)

Species Proposed for Listing as Threatened or Endangered

- Mountain plover - C*haradrius montanus*

Candidate for Listing as Threatened or Endangered

- Black-tailed prairie dog - C*ynomys ludovicianus*

Bozeman Trail

No surface development will be permitted on the following parcels along the Bozeman Trail in Converse County (1,030 acres).

T36N, R74W, Sec. 22, E1/2E1/2NE1/4

T38N, R74W, Sec. 2, NENESW, N1/2NWSW, NWNE, SWNE, NENW, SENW

T39N, R74W, Sec. 34, NE1/4, E1/2E1/2NW, E1/2SE
Sec. 35, SW1/4, SWNW

T40N, R75W, Sec. 24, W1/2SE
Sec. 25, NE1/4

T40N, R74W, Sec 31, W1/2NW

Current Stipulations

Every two months, each Field Office receives a list of lease parcels proposed for sale. Each parcel is reviewed by resource specialists for compliance to the resource concerns identified in the RMP. Part of this review includes completion of the Documentation of Land Use Plan Conformance and NEPA Adequacy (DNA) worksheet. If there are no additional resource value concerns, the parcels will only have Lease Notice # 1 attached. Each parcel is reviewed and pertinent lease notices/stipulations are attached.

After the lease parcels are reviewed, they are sent to the Wyoming State Office mineral leasing section to be included in the next competitive sale auction held in Cheyenne. A company that successfully bids on and obtains a lease parcel is mandated to comply with the stipulations contained on the lease unless the company receives written exception, modification, or waiver of the lease stipulations. Additionally a company is mandated to comply with Federal mandates such as Historic Preservation Act, and Endangered Species Act should these resources be identified before or during construction.

The BLM and FS have applied a variety of stipulations to oil and gas leases on federally administered lands within the Project Area. Although similarities exist, the stipulations vary by management area (BFO Area, CFO Area, and TBNG). The stipulations currently being applied to leases within each management area are discussed below.

Buffalo Field Office Area

This section lists the stipulations that will be applied and a short explanation of the reasons for each stipulation.

Resource:	**Special Management Areas**
Stipulation:	No Surface Occupancy
Objective:	To preclude surface-disturbing activities or occupancy within special management areas, such as state big game winter ranges, Red Wall, Hole-in-the-Wall, Middle Fork Canyon, Mosier

Gulch, Petrified Tree, Fortification Creek, Cantonment Reno, and Dullknife Battlefield.

Waiver: A waiver may be granted if it is determined that the action could occur without causing significant adverse impacts.

Exception: None

Modification: None

Justification: Each of these areas contains one or a combination of important resources such as wildlife habitat, wildlife diversity, high visual quality, and significant cultural, historic, or paleontological values.

Resource: Crucial Elk Winter Range

Stipulation: Timing Limitation

Objective: To preclude new surface-disturbing activities within crucial elk winter range, which could cause increased stress and/or displacement of animals during the critical time period (November 15 to April 30).

Waiver: A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used as winter range. A waiver also may be granted if, after consultation with the Wyoming Game and Fish Department, it is determined that activities within the area would help temporarily disperse the elk from areas of intense use and provide a tool for herd management.

Exception: An exception may be granted if seasonal conditions (e.g., an early spring and snowmelt) are such that the elk have moved out of and are not using the general area during the particular year.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as winter range.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 140 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the wintering period would have minimal effects on the elk.

Resource: Elk Calving

Stipulation: Timing Limitation

Objective: To preclude new surface-disturbing activities within elk calving areas, which could cause increased stress and/or displacement of animals during the critical time period (May 1 to June 30).

Waiver: A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used as a calving area. A waiver also may be granted if, after consultation with the Wyoming Game and Fish Department, it is determined that activities within the area would help temporarily disperse the elk from areas of intense use and provide a tool for herd management.

Exception: An exception may be granted if seasonal conditions (e.g., an early spring and snowmelt) are such that the elk have moved out of and are not using the general area during the particular year.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as a calving area.

Justification: This stipulation is need to reduce effects of stress during the calving season.

Resource: **Sage Grouse Breeding Areas**

Stipulation: Controlled Surface Use

Objective: To minimize adverse effects, activities within ¼ mile of a sage grouse strutting/dancing ground will be restricted or prohibited.

Waiver: A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used by sage grouse as a breeding area. A waiver also may be granted if the operator and surface management agency arrive at an acceptable plan for mitigation of anticipated effects.

Exception: None.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as a breeding area.

Justification: A CSU stipulation is needed to ensure minimal effects on integrity and use of sage grouse breeding areas. The No Lease option or NSO stipulation were deemed to be overly restrictive because operations could be conducted outside the ¼ mile buffer around the breeding area with minimal effects on the sage grouse.

Resource: **Sage Grouse Nesting Habitats**

Stipulation: Timing Limitation

Objective: To preclude new surface-disturbing activities within sage grouse nesting habitats an additional 1 ¾ radius beyond the ¼ mile lek radius, which could cause increased stress and/or displacement of animals during the critical time period (March 1 to June 15).

Waiver: A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used by sage grouse as nesting habitat.

Exception: An exception may be granted if seasonal conditions are such that the sage grouse have moved out of and are not using the general area during the particular year.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as nesting habitat.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 150 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on the sage grouse.

Resource: Sharp-tailed Grouse Breeding Areas

Stipulation: Controlled Surface Use

Objective: To minimize adverse effects, activities within 250 yards of a sharp-tailed grouse strutting/dancing ground will be restricted or prohibited.

Waiver: A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used by sharp-tailed grouse as a breeding area. A waiver also may be granted if the operator and surface management agency arrive at an acceptable plan for mitigation of anticipated effects.

Exception: None.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as a breeding area.

Justification: A CSU stipulation is needed to ensure minimal effects on integrity and use of sharp-tailed grouse breeding areas. The No Lease option or NSO stipulation were deemed to be overly restrictive because operations could be conducted outside the ¼ mile buffer around the breeding area with minimal effects on the sharp-tailed grouse.

Resource: Sharp-tailed Grouse Nesting Habitats

Stipulation: Timing Limitation

Objective: To preclude new surface-disturbing activities within sharp-tailed grouse nesting habitats, an additional ½ mile radius beyond the 250 yard lek radius, which could cause increased stress and/or displacement of animals during the critical time period (April 1 to May 31).

Waiver: A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used by sharp-tailed grouse as nesting habitat.

Exception: An exception may be granted if seasonal conditions are such that the sharp-tailed grouse have moved out of and are not using the general area during the particular year.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as nesting habitat.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 150 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on the sharp-tailed grouse.

Resource: Raptor Nesting Habitat

Stipulation: Timing Limitation

Objective: To preclude new surface-disturbing activities within ½-mile of raptor nest sites, which could cause increased stress and/or displacement of animals during the critical time period (February 1 to July 31).

Waiver: A waiver may be granted if new habitat studies, in coordination with the WGFD and FWS, concludes that the nest sites affected by this stipulation are no longer used by raptors.

Exception: An exception may be granted if seasonal conditions are such that the raptors have moved out of and are not using the nest sites during the particular year.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as nesting habitat.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 180 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on raptors.

Resource: Bald Eagle Winter Roosts

Stipulation: Timing Limitation

Objective: To preclude new surface-disturbing activities within 1-mile of bald eagle winter roosts, which could cause increased stress and/or displacement of animals during the critical time period (November 1 to April 1).

Waiver: A waiver may be granted if new habitat studies, in coordination with the WGFD and FWS, conclude that winter roosts affected by this stipulation are no longer used by bald eagles.

Exception: An exception may be granted if seasonal conditions are such that the bald eagles have moved out of and are not using the winter roost during the particular year.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as winter roosts.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 150 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the winter period would have minimal effects on bald eagles.

Resource: Bozeman Trail

Stipulation: Controlled Surface Use

Objective: To protect the cultural and scenic values of the Bozeman Trail, activities within ¼ mile or the visual horizon of the Bozeman Trail will be restricted or prohibited.

Waiver: A waiver may be granted if the operator and surface management agency arrive at an acceptable plan for mitigation of anticipated effects.

Exception: None.

Modification: None.

Justification: A CSU stipulation is needed to ensure minimal effects on the cultural and scenic values of the Bozeman Trail. The No Lease option or an NSO stipulation were deemed to be overly restrictive because operations could be conducted outside the ¼ mile buffer or visual horizon with minimal effects on the cultural and scenic values of the Bozeman Trail.

Resource: Fortification Creek Management Area

Stipulation: Controlled Surface Use

Objective: To protect the wildlife, scenic, and watershed values of the Fortification Creek Management Area.

Waiver: A waiver may be granted if the operator and SMA arrive at an acceptable plan for mitigation of anticipated effects.

Exception: None.

Modification: None.

Justification: A CSU stipulation is needed to ensure minimal effects on the wildlife, scenic, and watershed values in the Fortification Creek Management Area. The No Lease option or a NSO stipulation,

were deemed to be overly restrictive because operations could be conducted and facilities constructed (e.g., buried) with minimal effects on the wildlife, scenic, and watershed values.

Resource:	**Severe Erosion Hazard Areas**
Stipulation:	Timing Limitation
Objective:	To protect areas with severe erosion hazards from erosion.
Waiver:	Surface disturbing activities will be prohibited unless or until the permittee or the designated representative and the SMA arrive at an acceptable plan for mitigation of anticipated impacts.
Exception:	None.
Modification:	None.
Justification:	SLT provide for delay of activities for up to 60 days. Because the critical period may extend for much more than 60 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive.

Casper Field Office Area

The following are the resource values identified from the Platte River RMP for which stipulations may be applied:

Resource:	**Crucial Elk Winter Range**
Stipulation:	Timing Limitation
Objective:	To preclude new surface-disturbing activities within crucial elk winter range, which could cause increased stress and/or displacement of animals during the critical time period (November 15 to April 30).
Waiver:	A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used as winter range. A waiver also may be granted if, after consultation with the Wyoming Game and Fish Department, it is determined that activities within the area would help temporarily disperse the elk from areas of intense use and provide a tool for herd management.
Exception:	An exception may be granted if seasonal conditions (e.g., an early spring and snowmelt) are such that the elk have moved out of and are not using the general area during the particular year.
Modification:	A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as winter range.
Justification:	SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 140 days, the SLT would not

be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the wintering period would have minimal effects on the elk.

Resource: **Elk Calving**

Stipulation: Timing Limitation

Objective: To preclude new surface-disturbing activities within elk calving areas, which could cause increased stress and/or displacement of animals during the critical time period (May 1 to June 30).

Waiver: A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used as a calving area. A waiver also may be granted if, after consultation with the Wyoming Game and Fish Department, it is determined that activities within the area would help temporarily disperse the elk from areas of intense use and provide a tool for herd management.

Exception: An exception may be granted if seasonal conditions (e.g., an early spring and snowmelt) are such that the elk have moved out of and are not using the general area during the particular year.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as a calving area.

Justification: This stipulation is need to reduce effects of stress during the calving season.

Resource: **Sage Grouse Breeding Areas**

Stipulation: Controlled Surface Use

Objective: To minimize adverse effects, activities within ¼ mile of a sage grouse strutting/dancing ground will be restricted or prohibited.

Waiver: A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used by sage grouse as a breeding area. A waiver also may be granted if the operator and surface management agency arrive at an acceptable plan for mitigation of anticipated effects.

Exception: None.

Modification: A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as a breeding area.

Justification: A CSU stipulation is needed to ensure minimal effects on integrity and use of sage grouse breeding areas. The No Lease option or a NSO stipulation were deemed to be overly restrictive because operations could be conducted outside the ¼ mile buffer

around the breeding area with minimal effects on the sage grouse.

Resource:	**Sage Grouse Nesting Habitats**
Stipulation:	Timing Limitation
Objective:	To preclude new surface-disturbing activities within sage grouse nesting habitats, no surface use is allowed within 1 ¾ miles from the ¼ mile protection zone between March 1 and June 15 so that the nesting area around the strutting and dancing ground can be protected.
Waiver:	A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used by sage grouse as nesting habitat.
Exception:	The authorized officer may authorize exceptions to the time and distance limitations, in any particular year.
Modification:	A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as nesting habitat.
Justification:	A TL stipulation is needed to ensure minimal effects on integrity and use of sharp-tailed grouse nesting areas. The No Lease option or a NSO stipulation were deemed to be overly restrictive because operations could be conducted outside the ¼ mile buffer around the breeding area with minimal effects on the sage grouse.

Resource:	**Sharp-tailed Grouse Breeding Areas**
Stipulation:	Controlled Surface Use
Objective:	To minimize adverse effects, activities within ¼ mile of a sharp-tailed grouse strutting/dancing ground will be restricted or prohibited.
Waiver:	A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used by sharp-tailed grouse as a breeding area. A waiver also may be granted if the operator and surface management agency arrive at an acceptable plan for mitigation of anticipated effects.
Exception:	None.
Modification:	A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as a breeding area.
Justification:	A CSU stipulation is needed to ensure minimal effects on integrity and use of sharp-tailed grouse breeding areas. The No Lease

option or a NSO stipulation were deemed to be overly restrictive because operations could be conducted outside the ¼ mile buffer around the breeding area with minimal effects on the sharp-tailed grouse.

Resource:	**Sharp-tailed Grouse Nesting Habitats**
Stipulation:	Timing Limitation
Objective:	To preclude new surface-disturbing activities within sharp-tailed grouse nesting habitats, no surface use is allowed within 1 ¾ miles from the ¼ mile protection zone between March 1 and June 15 so that the nesting area around the strutting and dancing ground can be protected.
Waiver:	A waiver may be granted if new habitat studies in coordination with the Wyoming Game and Fish Department conclude that the area affected by this stipulation is no longer used by sharp-tailed grouse as nesting habitat.
Exception:	The authorized officer may authorize exceptions to the time and distance limitations, in any particular year.
Modification:	A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as nesting habitat.
Justification:	A TL stipulation is needed to ensure minimal effects on integrity and use of sharp-tailed grouse nesting areas. The No Lease option or a NSO stipulation were deemed to be overly restrictive because operations could be conducted outside the ¼ mile buffer around the breeding area with minimal effects on the sharp-tailed grouse.

Resource:	**Raptor Nesting Habitat**
Stipulation:	Timing Limitation
Objective:	To preclude new surface-disturbing activities within ½-mile of raptor nest sites, which could cause increased stress and/or displacement of animals during the critical time period (February 1 to July 31).
Waiver:	A waiver may be granted if new habitat studies, in coordination with the WGFD and FWS, concludes that the nest sites affected by this stipulation are no longer used by raptors.
Exception:	An exception may be granted if seasonal conditions are such that the raptors have moved out of and are not using the nest sites during the particular year.
Modification:	A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as nesting habitat.

Justification:	SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 180 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on raptors.
Resource:	**Bald Eagle Winter Roosts**
Stipulation:	No Surface Occupancy
Objective:	To preclude new surface-disturbing activities within 1-mile of bald eagle winter roosts, which could cause increased stress and/or displacement of animals during the critical time period (November 1 to April 1).
Waiver:	A waiver may be granted if new habitat studies, in coordination with the WGFD and FWS, conclude that winter roosts affected by this stipulation are no longer used by bald eagles.
Exception:	An exception may be granted if seasonal conditions are such that the bald eagles have moved out of and are not using the winter roost during the particular year.
Modification:	A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as winter roosts.
Justification:	SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 150 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the winter period would have minimal effects on bald eagles.
Resource:	**Bald Eagle Winter Roosts**
Stipulation:	Timing Limitation
Objective:	To preclude new surface-disturbing activities within 1-mile of bald eagle winter roosts, which could cause increased stress and/or displacement of animals during the critical time period (November 1 to April 1).
Waiver:	A waiver may be granted if new habitat studies, in coordination with the WGFD and FWS, conclude that winter roosts affected by this stipulation are no longer used by bald eagles.
Exception:	An exception may be granted if seasonal conditions are such that the bald eagles have moved out of and are not using the winter roost during the particular year.
Modification:	A modification of the stipulation may be granted if new habitat studies show that a portion of the area is not used as winter roosts.
Justification:	SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 150 days, the SLT would not

be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the winter period would have minimal effects on bald eagles.

On public lands, surface development will be prohibited on an area from ¼ to 1 mile of known or discovered nests. The specific distance and dimensions of the area on which surface development will be prohibited will be determined on a case-by-case basis after consultation with the USFWS in accordance with the Endangered Species Act.

Thunder Basin National Grassland

Two distinct sets of stipulations are presented below. Currently, the 1985 LRMP for the TBNG (FS 1985) and the 1994 oil and gas leasing analysis and EIS (FS 1994) provide the direction for the management of oil and gas on the TBNG. However, the FS prepared a new LRMP for the TBNG in 2001. A decision on this proposed LRMP is expected early in 2002. Because this decision may be to implement the new 2001 LRMP, the stipulations associated with both LRMPs are presented below.

Current Land and Resource Management Plan (1985)

Resource: **Wildlife**

Stipulation: Timing Limitation

Objective: To prevent oil and gas activities from causing degradation of the crucial wildlife habitat for Forest Plan Management Indicator Species, surface occupancy or use is subject to the following operating constraints:

1. No activities shall be allowed within one mile of an active bald eagle nest or peregrine falcon nest from February 1 to July 31, if they would cause nesting failure or abandonment.
2. No activities shall be allowed within one-quarter mile of an active golden eagle nest form February 1 to July 31, if they would cause nesting failure or abandonment.
3. No activities shall be allowed within one-quarter mile of an active ferruginous hawk, Swainson's hawk, goshawk, osprey or prairie falcon nest from March 1 to July 31, if they would cause nesting failure or abandonment.
4. No activities shall be allowed within one-quarter mile of any rookery from March 1 to July 31, if they would cause abandonment of the rookery, unless specific practices are successfully implemented to maintain or increase the opportunities at other rookery sites.

Waiver: Waivers will be considered in accordance with the requirements of Title 36 Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in

considering the request. The Deciding Officer's decision will be based on this information.

Exception: Exceptions will be considered in accordance with the requirements of Title 36 Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Modification: Modifications will be considered in accordance with the requirements of Title 36 Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Justification: Forest Plan direction pages III-29 thru III-36. Allowing development in crucial wildlife habitat for Management Indicator Species without special consideration generates an unacceptable risk of causing habitat degradation. Additionally many of the Management Indicator Species are protected by law and the stipulation is to insure compliance with these laws.

Resource: Wildlife

Stipulation: Controlled Surface Use

Objective: To prevent degrading crucial wildlife habitat for Forest Plan Management Indicator Species by oil and gas activities, surface occupancy or use is subject to the following operating constraints.

1. No activities shall be allowed within one-half mile of an active bald eagle or peregrine falcon nest at any time if they would cause disturbance of the adult birds on the nest.
2. No activities shall be allowed within 300 feet of any ferruginous hawk, Swainson's hawk, goshawk, osprey or prairie falcon nest at any time if they would cause nest abandonment, unless specific practices are successfully implemented to maintain or increase nesting opportunities at other sites. This does not apply to existing surface occupancies.
3. New roads or other developments shall be place out of sight of the existing raptor nest if possible, unless specific practices are successfully implemented to maintain or increase nesting opportunities.
4. No activities shall be allowed within one-quarter mile of a sage grouse or sharp-tailed grouse lek at any time if they would cause abandonment of the lek, unless specific practices are successfully implemented to maintain or increase the existing habitat capability for grouse.

Waiver: Waivers will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be con-

ducted in considering the request. The Deciding Officer's decision will be based on this information.

Exception: Exceptions will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Modification: Modifications will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Justification: Forest Plan direction pages III-29 thru III-36. Allowing development in crucial wildlife habitat for Management Indicator Species without special consideration generates an unacceptable risk of causing habitat degradation. Additionally, many of the Management Indicator Species are protected by law and the stipulation is to insure compliance with these laws.

Resource: **Wildlife**

Stipulation: Controlled Surface Use

Objective: To prevent degrading crucial wildlife habitat for Forest Plan Management Indicator Species by oil and gas activities and, in response to public comment, to protect golden eagle nests, anytime within 300 feet, surface occupancy or use is subject to the following operating constraints:

1. No activities shall be allowed within one-half mile of an active bald eagle or peregrine falcon nest at any time if they would cause disturbance of the adult birds on the nest.
2. No activities shall be allowed within 300 feet of any ferruginous hawk, Swainson's hawk, goshawk, osprey or prairie falcon nest at any time if they would cause nest abandonment, unless specific practices are successfully implemented to maintain or increase nesting opportunities at other sites. This does not apply to existing surface occupancies.
3. New roads or other developments shall be place out of sight of the existing raptor nest if possible, unless specific practices are successfully implemented to maintain or increase nesting opportunities.
4. No activities shall be allowed within one-quarter mile of a sage grouse or sharp-tailed grouse lek at any time if they would cause abandonment of the lek, unless specific practices are successfully implemented to maintain or increase the existing habitat capability for grouse.

Waiver: Waivers will be considered in accordance with the requirements of Title 36 Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in

considering the request. The Deciding Officer's decision will be based on this information.

Exception: Exceptions will be considered in accordance with the requirements of Title 36 Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Modification: Modifications will be considered in accordance with the requirements of Title 36 Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Justification: Forest Plan direction pages III-29 thru III-36. Allowing development in crucial wildlife habitat for Management Indicator Species without special consideration generates an unacceptable risk of causing habitat degradation. Additionally, many of the Management Indicator Species are protected by law and the stipulation is to insure compliance with these laws.

Resource: **Soil and Water**

Stipulation: Controlled Surface Use

Objective: To prevent land slides and mass soil movements being caused by oil and gas activities, surface occupancy or use is subject to the following operating constraints:

On areas identified as having a high potential for soil mass wasting and on unstable areas with slopes greater than 34 percent but less than 60 percent no surface occupancy will be allowed unless:

1. No other reasonable alternatives exist, and
2. It is established to the authorized officer's satisfaction, that the site specific design for the facilities will not cause massive soil movement.

Waiver: Waivers will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Exception: Exceptions will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Modification: Modification will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be

conducted in considering the request. The Deciding Officer's decision will be based on this information.

Justification: Forest Plan direction, Page III-58, Item c, page III-59, Items c.1 and c.2. and pages III-74 through III-76. Areas within the classification of "mass wasting potential areas" and slopes under 60 percent and over 34 percent that are unstable. Using these areas for the development of the oil and gas resource generates a risk of massive soil movement.

Resource: **Soil and Water**

Stipulation: Controlled Surface Use

Objective: To prevent oil and gas activities causing a significant and permanent decrease in soil productivity, surface occupancy or use is subject to the following operating constraints:

On areas identified as having a high potential for soil mass wasting and on unstable areas with slopes greater than 34 percent but less than 60 percent no surface occupancy will be allowed unless:

1. No other reasonable alternatives exist, and
2. It is established to the authorized officer's satisfaction, that the site specific design for the facilities will not cause massive soil movement.

Waiver: Waivers will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Exception: Exceptions will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Modification: Modification will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Justification: Forest Plan direction, Page III-58, Item c, page III-59, Items c.1 and c.2. and pages III-74 through III-76. Areas within the classification of "mass wasting potential areas" and slopes under 34 percent are unstable if disturbed significantly. Using these areas for the development of the oil and gas resources, including roads and pipelines, requires special consideration.

Riparian soils are sensitive and easily damaged. Using these areas for the development of the oil and gas resource, including roads and pipelines, requires special consideration.

Resource: **Soil and Water**

Stipulation: Controlled Surface Use

Objective: To prevent oil and gas activities from causing degradation of the riparian, playas, floodplains and wetland values, surface occupancy or use if subject to the following operating constraints:

1. No other reasonable alternatives exist and
2. It is established to the authorized officer's satisfaction that the development will meet Forest Plan Standards and Guidelines about riparian, playas, floodplains and wetland areas.
   a. Design activities to protect and manage the riparian ecosystem.
      1. Initiate timely and effective rehabilitation of disturbed areas. Restore riparian areas so that a vegetation ground cover or suitable substitute protects the soil from erosion and prevents increased sediment yield.
      2. Maintain the integrity of the ecosystem including quantity and quality of water.
   b. Locate oil and gas activities away from the water's edge or outside the riparian areas, playas, wetlands, and floodplains unless alternatives have been assessed and determined to be more environmentally damaging. If necessary to locate activities in these areas, then:
3. Deposit no waste material (silt, sand, gravel, soil, slash, debris, chemicals, or other material) below high water lines, in riparian areas, in areas immediately adjacent to riparian areas or in natural drainageways (draws, land surface depressions or other area where overland flow concentrates and flows directly into streams or lakes).
4. Prohibit the depositing of soil material from drilling, processing or site preparation in natural drainageways.
5. Locate the lower edge of disturbed or deposited soil banks outside the active floodplain.
6. Prohibit stockpiling of topsoil or any other disturbed soil in the active floodplain.
7. Locate drilling mud pits outside riparian areas, playas, wetlands, and floodplains. If location is unavoidable in these areas, seal and dike all pits to prevent leakage.
8. Drain and restore roads, pads and drill sties immediately after use is discontinued. Revegetate to 80 percent of ground cover in the first year. Provide surface protection during stormflow and snowmelt runoff events.

9. Avoid constructing roads, drill pads and tank batteries in, or immediately adjacent to riparian areas, playas, wetlands and floodplains. Facilities will be located a sufficient distance form the water's edge so that sediment entering the water is minimized.
10. Gravel pits shall be rehabilitated to simulate a natural riparian/aquatic situation if permitted in riparian zones.
11. Do not parallel streams when road location must occur in riparian areas except where absolutely necessary. Cross streams at right angles. Locate crossings at points of low bank slope and firm surfaces.

c. Riparian areas, playas, floodplains and wetlands; will not exceed a visual quality objective (VQO) of partial retention. This visual management system, as well as the terms partial retention and visual quality objective, are explained in the Forest Service manuals and handbooks.

Waiver: Waivers will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Exception: Exceptions will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Modification: Modifications will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Justification: Forest Plan direction pages III-51 through III-53 and pages III-74 through III-76. Riparian areas, playas, floodplains and wetlands are sensitive. Utilizing them for the development of the oil and gas resource without special consideration causes an unacceptable risk of degradation of their values.

Resource: Soil and Water

Stipulation: No Surface Occupancy

Objective: To prevent oil and gas activities form causing land slides and similar massive soil movements, no surface occupancy or use is allowed on the lands described below:

This stipulation is to be applied to the mass wasting potential areas with slopes of, or over 60 percent as identified on the Project map Record for the Oil and Gas Leasing EIS (1:24,000 Soils maps).

In general, larger areas meeting these criteria are located on side slopes of the Rochelle Hills, Miller Hills, Red Hills, HA Divide, Cow Creek Buttes and portions of the Spring Creek unit. Areas less than 40 acres meeting these criteria are scattered throughout the National Grassland.

Waiver: Waiver will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Exception: Exceptions will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Modification: Modifications will be considered in accordance with the requirements of Title 36, Code of Federal Regulations Part 228. Environmental analysis meeting the requirements of NEPA will be conducted in considering the request. The Deciding Officer's decision will be based on this information.

Justification: Forest Plan direction, Page III-58, Item c, and page III-59, Items c.1. and c.2. Areas with a classification of "mass wasting potential areas" and with slopes over 60 percent are unstable, using these areas for the development of the oil and gas resource causes an unacceptable risk of massive soil movement.

Proposed Land and Resource Management Plan (2001)

Resource: Water, Wetlands, Woody Draws, Riparian, and Floodplains

Stipulation: Controlled Surface Use

Objective: To protect the biological and hydrologic features of riparian areas, woody draws, wetlands, and floodplains.

Waivers: This stipulation may be waived if the authorized officer determines the entire leasehold no longer contains any riparian areas, woody draws, wetlands, or floodplains.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated.

Modifications: The boundaries of the stipulated area may be modified if the authorized officer determines that portions of the area do not include riparian areas, woody draws, wetlands, and floodplains.

Justification: A CSU stipulation is needed to ensure minimal effects on riparian areas, woody draws, wetlands, and floodplains. The No Lease option or an NSO stipulation were deemed to be overly restrictive because operations could be conducted in a way that re-

sults in minimal effects on riparian areas, woody draws, wetlands, and floodplains.

Resource: Slopes Greater than 40 Percent

Stipulation: No Surface Occupancy

Objective: To protect soil resources from loss of productivity, prevent erosion on steep slopes (greater than 40 percent), soil mass movement, and resultant sedimentation.

Waivers: This stipulation may be waived if the authorized officer determines conditions have changed and the entire leasehold no longer contains any slopes greater than 40 percent.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area do not include slopes greater than 40 percent.

Justification: A NSO stipulation is needed to ensure minimal effects on slopes greater than 40 percent. The No Lease option was deemed to be overly restrictive because operations could be conducted in a way that results in minimal effects on slopes greater than 40 percent.

Resource: Fossils

Stipulation: Controlled Surface Use

Objective: To protect fossils and immediate environment of the site, including inherent scientific, natural historic, interpretive, educational, and recreational values for the area potentially affected.

Waivers: No conditions for a waiver are anticipated, and approval of a waiver would be unlikely.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area do not include significant fossils.

Justification: A CSU stipulation is needed to ensure minimal effects on significant fossils. The No Lease option or an NSO stipulation were deemed to be overly restrictive because operations could be conducted in a way that results in minimal effects on fossils.

Resource:	**Ferruginous Hawk and Swainson's Hawk Nests**
Stipulation:	Timing Limitation
Objective:	To prevent reduced reproductive success, new surface-disturbing activities are prohibited from March 1 through July 31 within ½-mile of ferruginous and Swainson's hawk nests.
Waivers:	This stipulation may be waived if the authorized officer determines conditions have changed and all nests within the leasehold or within the stipulated distance from the leasehold are known to have been unoccupied during each of the previous 7 years.
Exceptions:	The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable, can be adequately mitigated, or if all nests within the leasehold or within the stipulated distance from the leasehold are known to have been unoccupied during each of the previous 7 years.
Modifications:	The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area include nests or nest site(s) known to have been unoccupied during each of the previous 7 years.
Justification:	SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 150 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on ferruginous and Swainson's hawks.

Resource:	**Golden Eagle Nests**
Stipulation:	Surface use is prohibited from February 1 through July 31 within 0.50 miles (line of sight) of golden eagle nests.
Objective:	To prevent reduced reproductive success, new surface-disturbing activities are prohibited from February 1 through July 31 within ½-mile of golden eagle nests.
Waivers:	This stipulation may be waived if the authorized officer determines conditions have changed and all nests within the leasehold or within the stipulated distance from the leasehold are known to have been unoccupied during each of the previous 7 years.
Exceptions:	The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable, can be adequately mitigated, or if all nests within the leasehold or within the stipulated distance from the leasehold are known to have been unoccupied during each of the previous 7 years.
Modifications:	The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area include

nests or nest site(s) known to have been unoccupied during each of the previous 7 years.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 180 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on golden eagles.

Resource: **Merlin Nests**

Stipulation: Timing Limitation

Objective: To prevent reduced reproductive success, new surface-disturbing activities are prohibited from April 1 through August 15 within ½-mile of merlin nests.

Waivers: This stipulation may be waived if the authorized officer determines conditions have changed and all nests within the leasehold or within the stipulated distance from the leasehold are known to have been unoccupied during each of the previous 7 years.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable, can be adequately mitigated, or if all nests within the leasehold or within the stipulated distance from the leasehold are known to have been unoccupied during each of the previous 7 years.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area include nests or nest site(s) known to have been unoccupied during each of the previous 7 years.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 140 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on merlins.

Resource: **Sage Grouse Display Grounds**

Stipulation: Timing Limitation

Objective: To prevent abandonment of display grounds and reduced reproductive success, surface use is prohibited from March 1 through June 15 within 2 miles (line of sight) of a sage grouse display ground, and noise from production facilities must not exceed 49 decibels (10 dBA above background noise) at the display ground.

Waivers: This stipulation may be waived if the authorized officer determines conditions have changed and all display grounds within

the leasehold or within the stipulated distance from the leasehold have not been used during the past 5 breeding seasons.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated. An exception may be granted if the display ground has not been used by May 1 of the current year.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area do not include any display grounds that have been used during the past 5 breeding seasons.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 110 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on the sage grouse.

Resource: **Mountain Plover**

Stipulation: Timing Limitation

Objective: To prevent reduced reproductive success, surface use is prohibited from March 15 through July 31 within 0.25 miles (line of sight) of a mountain plover nests or nest aggregation areas.

Waivers: This stipulation may be waived if the authorized officer determines conditions have changed and there are no nests or nest aggregation areas within the leasehold or within the stipulated distance from the leasehold.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated. An exception may be granted if the nest or nest aggregation area has not been used by June 10 of the current year.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area do not include mountain plover nests and nesting areas.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 140 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on mountain plovers.

Resource: **Swift Fox Dens (TL)**

Stipulation: Timing Limitation

Objective: To prevent den abandonment and reduced reproductive success, new surface-disturbing activities are prohibited from March 1

through August 31 within 0.25 mile (line of sight) of swift fox dens.

Waivers: This stipulation may be waived if the authorized officer determines conditions have changed and there are no dens within the leasehold or within the stipulated distance from the leasehold.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area do not include swift fox dens.

Justification: SLT provide for delay of activities for up to 60 days. Because the critical period extend for about 180 days, the SLT would not be adequate. The No Lease option or an NSO were deemed to be overly restrictive because operations conducted outside the nesting period would have minimal effects on swift foxes.

Resource: Mountain Plover Habitat

Stipulation: Controlled Surface Use

Objective: To prevent reductions in reproductive success, operations in mountain plover nesting and brooding habitat are subject to the following constraints:

- Limit oil and gas development to no more than one location per 80 acres.
- Suitable mountain plover habitat lost because of new facilities must be replaced within 1 year.
- Access for routine maintenance of oil and gas facilities in mountain plover nesting and brooding habitat will be between 9 am and 5 pm. This does not apply to emergency repairs.
- If it is necessary to place a new road in a prairie dog colony, align the road to minimize habitat loss.

Waivers: No conditions for a waiver are anticipated, and approval of a waiver would be unlikely.

Exceptions: No conditions for an exception are anticipated, and approval of an exception would be unlikely.

Modifications: The boundary of the stipulated area may be modified if the authorizing officer determines that portions or the area do not contain active prairie-dog colonies.

Justification: A CSU stipulation is needed to ensure minimal effects on mountain plover habitat. The No Lease option or an NSO stipulation were deemed to be overly restrictive because operations could be

conducted in a way that results in minimal effects on mountain plovers.

Resource: **Mountain Plover Nests and Nesting Areas**

Stipulation: No Surface Occupancy

Objective: To prevent reduced reproductive success and adverse habitat loss, no surface occupancy or use is allowed within 0.25 miles of known mountain plover nests or nesting areas.

Waivers: No conditions for a waiver are anticipated, and approval of a waiver would be unlikely.

Exceptions: No conditions for an exception are anticipated, and approval of an exception would be unlikely.

Modifications: The boundary of the stipulated area may be modified if the authorizing officer determines that portions or the area do not contain active black-tailed prairie dogs colonies.

Justification: An NSO stipulation is needed to ensure minimal effects on mountain plover nests and nesting areas. The No Lease option or was deemed to be overly restrictive because operations could be conducted in a way that results in minimal effects on mountain plover nests and nesting areas.

Resource: **Bald Eagle Nests**

Stipulation: No Surface Occupancy

Objective: To prevent reduced reproductive success and adverse habitat loss, no surface occupancy or use is allowed within 1.0 mile (line of sight) of bald eagle nests.

Waivers: This stipulation may be waived if the authorized officer determines conditions have changed and all nests within the leasehold or within the stipulated distance from the leasehold are known to have been unoccupied during each of the previous 7 years.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area include nests or nest site(s) known to have been unoccupied during each of the previous 7 years. The boundary of the stipulated area may also be modified if the authorized officer determines that portions of the area can be occupied without adversely affecting the eagles.

Justification: An NSO stipulation is needed to ensure minimal effects on bald eagle nests. The No Lease option or was deemed to be overly re-

strictive because operations could be conducted in a way that results in minimal effects on bald eagle nests.

Resource: **Golden Eagle, Merlin, Ferruginous Hawk, Swainson's Hawk, and Burrowing Owl Nests**

Stipulation: No Surface Occupancy

Objective: To prevent reduced reproductive success and adverse habitat loss, no surface occupancy or use is allowed within 0.25 mile (line-of-sight) of golden eagle, merlin, ferruginous hawk, Swainson's hawk, or burrowing owl nests.

Waivers: This stipulation may be waived if the authorized officer determines conditions have changed and all nests within the leasehold or within the stipulated distance from the leasehold are known to have been unoccupied during each of the previous 7 years.

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area include nests or nest site(s) known to have been unoccupied during each of the previous 7 years. The boundary of the stipulated area may also be modified if the authorized officer determines that portions of the area can be occupied without adversely affecting these raptors.

Justification: An NSO stipulation is needed to ensure minimal effects on golden eagle, merlin, ferruginous hawk, Swainson's hawk, and burrowing owl nests. The No Lease option or was deemed to be overly restrictive because operations could be conducted in a way that results in minimal effects on golden eagle, merlin, ferruginous hawk, Swainson's hawk, and burrowing owl nests.

Resource: **Sharp-tailed Grouse and Sage Grouse Display Grounds**

Stipulation: no surface occupancy or use is allowed within 0.25 mile (line-of-sight) of a sharp-tailed grouse or sage grouse display ground.

Objective: To prevent abandonment of display grounds, reduced reproductive success, and adverse habitat loss, no surface occupancy or use is allowed within 0.25 mile (line-of-sight) of a sharp-tailed grouse or sage grouse display ground.

Waivers: This stipulation may be waived if the authorized officer determines conditions have changed and all display grounds within the leasehold or within the stipulated distance of the leasehold have not been used during the last 2 breeding seasons (sharp-tailed grouse) or 5 breeding seasons (sage grouse).

Exceptions: The authorizing officer may grant an exception to this stipulation if the operator submits a plan that demonstrates impacts from the proposed action are acceptable or can be adequately mitigated.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area do not include any display grounds that have been used during the last 2 breeding seasons (sharp-tailed grouse) or 5 breeding seasons (sage grouse). The boundary of the stipulated area may also be modified if the authorized officer determines that portions of the area can be occupied without adversely affecting sage grouse and the display grounds.

Justification: An NSO stipulation is needed to ensure minimal effects on sharp-tailed grouse or sage grouse display grounds. The No Lease option or was deemed to be overly restrictive because operations could be conducted in a way that results in minimal effects on sharp-tailed grouse or sage grouse display grounds.

Resource: Moderate Scenic Integrity Objective (SIO) Areas

Stipulation: Controlled Surface Use

Objective: To maintain the scenic integrity objective (SIO) for areas identified as moderate, surface occupancy and use is subject to operational constraints to maintain a landscape character that is no more than slightly altered. Noticeable deviations must remain visually subordinate to the landscape character being viewed.

Waivers: No conditions for a waiver are anticipated, and approval of a waiver is unlikely.

Exceptions: No conditions for an exception are anticipated, and approval of an exception is unlikely.

Modifications: The boundaries of the stipulated area may be modified if the authorizing officer determines that portions of the area do not include moderate SIO areas.

Justification: A CSU stipulation is needed to ensure minimal effects on moderate scenic integrity objective areas. The No Lease option or an NSO stipulation were deemed to be overly restrictive because operations could be conducted in a way that results in minimal effects on moderate scenic integrity objective areas.

Proposed Stipulations

Buffalo Field Office Area

None

Casper Field Office Area

None

Thunder Basin National Grassland

Same as those proposed under the 2001 Final Land and Resource Management Plan.

Proposed Plan Amendments

Buffalo and Platte River Resource Management Plans

The Agency Preferred Alternative would result in an amendment to the Buffalo and Platte River RMPs. The RMP decisions with this alternative would be to continue oil and gas exploration and development including coal bed methane at the higher level of intensity evaluated in this alternative and including new mitigation measures.

Thunder Basin National Grassland

None

Chapter 6
Consultation with Others

Chapter 6 — Consultation with Others

Agencies, companies, and organizations consulted by the BLM, FS, and State of Wyoming agencies cooperating in the analysis include the following:

Apache Tribe of Oklahoma
Blackfeet Tribal Business Council
BLM – Montana
Cheyenne and Arapaho Business Committee
Cheyenne River Sioux Tribal Council
Confederated Salish and Kootenai Tribal Council
Crow Creek Lakota Tribal Council
Crow Tribal Administration
Crow Tribal Council
Flandreau Santee Lakota Executive Comm.
Fort Belknap Community Council
Fort Peck Tribal Executive Board
Kiowa Tribe of Oklahoma
Lower Brule Lakota Tribal Council
Northern Arapaho Business Council
Northern Cheyenne Tribal Council
Powder River Energy Corporation
Rosebud Sioux Tribal Council
Shoshone Business Council
Sisseton-Wahpeton Lakota Tribal Council
Spirit Lake Lakota Tribal Council
Standing Rock Lakota Tribal Council
Three Affiliated Tribes Business Council
Turtle Mountain Chippewa
U.S. Environmental Protection Agency
Western Gas Resources, Inc.
Wyoming Outdoor Council
Yankton Lakota Tribe

Chapter 7
Preparers and Contributors

Chapter 7 — Preparers and Contributors

This EIS was prepared by Greystone, a third-party contractor, under the direction of the BLM. Representatives from the cooperating agencies contributed to and participated in the NEPA process. Technical input regarding the proposed project was provide by the Companies. Table 7–1 through Table 7–6 present the names of individuals and their area or areas of responsibility from the BLM, FS, Greystone, Applied Hydrology Associates, Inc., and Argonne National Laboratories who were involved in the preparation of this EIS. Brief biographical information also is presented.

Table 7–1 U.S. Department of Interior, Bureau of Land Management

Name	Project Responsibility
Buffalo Field Office	
Paul Beels	Project Manager
Jim Baker	Recreation Resources and GIS
Elizabeth Burghard	Cultural and Paleontological Resources
BJ Earl	Cultural and Paleontological Resources
Willy Frank	Minerals – Oil and Gas
Larry Gerard	Wildlife, Special Status, Fisheries, Vegetation, Wetlands, and Riparian
Larry Grey	Water Resources
Steve Hannan	Rangeland and Grazing
Bob Harman	Minerals- Oil and Gas
John Kolnik	Land Use
Jerry Queen	Geology
Rob Wilson	Cultural and Paleontological Resources
Richard Zander	Document Review
Casper Field Office	
Chris Arthur	Cultural and Paleontological
Jim Bauer	Reclamation and Minerals – Oil and Gas
Mike Brogan	Water Resources
Eve Bennett	Visual and Recreation Resources
Nancy Doelger	Minerals – Coal
Charlie Fifield	Rangeland and Grazing

Table 7–1 U.S. Department of Interior, Bureau of Land Management

Name	Project Responsibility
Willie Fitzgerald	Wildlife, Special Status Species, Fisheries
Charlie Gaskill	Minerals – Coal
Joe Meyer	Water, Soils, and Reclamation
Glen Nebeker	General Contact/ NEPA and Planning Conformance
Randy Sorenson	Land Use
Bob Specht	Geology and Minerals
George Soehn	Vegetation, Wetlands, Riparian
Don Whyde	Recreation Resources
Wyoming State Office	
Susan Kaplan	Air Quality
Roy Allen	Socioeconomics
National Science and Technology Center	
Scott Archer	Air Quality

Table 7–2 U.S. Department of Agriculture, Forest Service

Name	Project Responsibility
Joe Reddick	Project Coordination
JoAnne Homuth	Project Coordination and Review
William Steenson	NEPA Review
Melody Holm	Minerals Review

Table 7–3 State, Local, and Cooperating Agencies

Name	Agency	Position
John Robitaille	Wyoming Business Council	Minerals, Energy & Transportation Program Manager
Steve Reynolds	Wyoming Business Council	
Don Christianson	Wyoming Department of Agriculture	Director
Darla Potter	Wyoming Department of Environmental Quality	Environmental Analyst

Table 7–3 State, Local, and Cooperating Agencies

Name	Agency	Position
Dennis Hemmer	Wyoming Department of Environmental Quality	Director
Gary Beach	Wyoming Department of Environmental Quality	Water Quality Division Administrator
John Wagner	Wyoming Department of Environmental Quality	
Tim Stark	Wyoming Department of Transportation	Environmental Services
Tom Collins	Wyoming Game and Fish Department	Environmental Services Coordinator
Lance Cook	Wyoming Geological Survey	State Geologist
Carol Kruse	Wyoming Office of Federal Lands Planning	Planning Consultant
Julie Hamilton	Wyoming Office of Federal Lands Planning	Planning Consultant
Susan Child	Wyoming Office of Federal Lands Planning	Planning Consultant
Tracy Williams	Wyoming Office of Federal Lands Planning	Planning Consultant
Ron Arnold	Wyoming Office of State Lands and Investments	Director
Don Likwartz	Wyoming Oil and Gas Conservation Commission	Director
Dick Stockdale	Wyoming State Engineer's Office	Deputy Engineer
Patrick Tyrrell	Wyoming State Engineer's Office	State Engineer
Richard Currit	Wyoming State Historic Preservation Office	SHPO Director
Mike Besson	Wyoming Water Development Commission	Director
Marilyn Connolly	Johnson County Comissioner	
Brenda Schladweiler	Campbell County Conservation District	
Mickey Steward	CBMCC Coordinator	
Bill Welles	Lake DeSmet Conservation District	

Table 7–4 Greystone — Third Party Contractor

Name	Project Responsibility	Education
David Cameron	Project Manager	B.A. Biology M.S. Terrestrial Ecology 23 years of experience
Lucy Bambrey	Cultural Resources	M. A. Anthropology B.A. Sociology 22 years experience
Sue Barker	Water Resources	B.A. Environmental Biology 11 years of experience
Kathryn Cloutier	Land Use and Transportation	MS. Environmental Management/Natural Resources B.A. Biology 15 years experience
Kyle Davenport	Soils	B.S. Environmental Science 2 years of experience
Sara Davis	Biological Resources	B.S. Botany 3 years of experience
Don Douglas	Noise	M.S. Meteorology B.S. Metrology 31 years of experience
Steve Faulk	Biological Resources	M.S. Biology B.S. Biology 6 years of experience
Chuck Florian	GIS	B.S. Natural Resource Management 7 years of experience
Patrick Golden	Biological Resources	B.A. Environmental Biology 7 years of experience
Mike Holle	GIS	B.S. Natural Resource Science Minor in Spatial Database Management Systems 7 years of experience
Mike Kolin	Engineering	M.S. Mining Engineering Engineer or Mines 32 years of experience
Keary Mullins	Socioeconomics	B.A. Environmental Biology 6 years of experience
Matt Schweich	Biological Resources	B.S. Natural Resource Management 6 years of experience
Carl Späth	Cultural Resources	Ph.D. Anthropology M.A. Anthropology B.A. Anthropology 30 years of experience

Table 7–4 Greystone — Third Party Contractor

Name	Project Responsibility	Education
Lisa Welch	Visual and Recreational Resources	B.S. Earth Science 10 years experience
Kathy Wilkerson	Geology, Minerals, and Water Resources	B.S. Geology 27 years of experience

Table 7–5 Applied Hydrology Associates, Inc. — Subcontractor

Name	Project Responsibility	Education
Michael Day	Project Manager for groundwater modeling	M.S. Hydrogeology B.S. Geology, math/Physics 22 years of experience
Adam Bedard	Groundwater Modeler	B.S. Civil Engineering 6 years of experience
Art O'Hayre	Surface Water Quality	Ph.D Forest Hydrology M.S. Hydrology B.S. Earth Resources/Watershed management 24 years of experience

Table 7–6 Argonne National Laboratories — Subcontractor

Name	Project Responsibility	Education
Kyong C. Chun	Air Quality Impact Assessment	Ph.D. Environmental Health Engineering 30 years of experience
Young-soo Chang	Air Quality Impact Modeling	Ph.D. Chemical Engineering 20 years of experience

Chapter 8
Distribution of the Draft EIS

Chapter 8 — Distribution and Review of the Draft EIS

The following list identifies the agencies, organizations, companies, and persons to whom the Draft EIS was sent.

Federal and State Officials

U.S. Senator Mike Enzi

U.S. Senator Craig Thomas

U.S. Representative Barbara Cubin

Wyoming State Senator Bill Barton

Wyoming State Senator John Schiffer

Wyoming State Representative George McMurtrey, M.D.

Federal Agencies

Federal Energy Regulatory Commission

U.S. Army Corps of Engineers (multiple offices)

U.S. Department of Energy

U.S. EPA, Office of Federal Activities

U.S. EPA, Region VIII

U.S. EPA, Office of Environmental Activities

U.S. Department of Energy

USDA, Forest Service (multiple offices)

USDA, Natural Resources Conservation Service (multiple offices)

USDI, Bureau of Indian Affairs (multiple offices)

USDI, Bureau of Land Management (multiple offices)

USDI, Bureau of Land Management, Denver Federal Center

USDI, Bureau of Land Management, Division of Planning

USDI, Bureau of Reclamation (multiple offices)

USDI, Bureau of Reclamation, Denver Federal Center

USDI, Fish & Wildlife Reference Service

USDI, Fish and Wildlife Service (multiple offices)

USDI, Geological Survey (multiple offices)

USDI, Minerals Management Services

USDI, National Park Service (multiple offices)

USDI, Office of Environmental Policy and Compliance

USDI, Office of Surface Mining (multiple offices)

USDI, Office of the Solicitor
USDOD, Air Force Environmental, Safety and Occupational Health

State Agencies

Montana Department of Environmental Quality
Wyoming Office of Federal Land Policy

Local Agencies

Campbell County Conservation District
Campbell County Land Use Planning Commission
Campbell County Planning Commission
City of Gillette
Converse County Conservation District
Lake DeSmet Conservation District
Powder River Conservation District
Sheridan County Conservation District

Tribal Organizations

Apache Tribe of Oklahoma
Blackfeet Tribal Business Council
Cheyenne and Arapaho Business Committee
Cheyenne River Sioux Tribal Council
Confederated Salish and Kootenai Tribal Council
Crow Creek Lakota Tribal Council
Crow Tribal Administration
Crow Tribal Council
Flandreau Santee Lakota Executive Comm.
Fort Belknap Community Council
Fort Peck Tribal Executive Board
Kiowa Tribe of Oklahoma
Lower Brule Lakota Tribal Council
Northern Arapaho Business Council
Northern Cheyenne Tribal Council
Rosebud Sioux Tribal Council
Shoshone Business Council
Sisseton-Wahpeton Lakota Tribal Council
Spirit Lake Lakota Tribal Council

Standing Rock Lakota Tribal Council
Three Affiliated Tribes Business Council
Turtle Mountain Chippewa
Yankton Lakota Tribe

Organizations

Citizens Oil & Gas Support Center
Coal Bed Methane Coalition
Gillette Area Groundwater Monitoring Org.
Grass Roots Advocate
Natural Resources Defense Council
Petroleum Association of Wyoming
Powder River Basin Resource Council
Prairie Hills Audubon Society
Public Lands Advocacy
Sierra Club, Northern Great Plains Reg.
Wildlife Management Institute
Wyoming Outdoor Council
Wyoming Wildlife Federation

Companies

Anderman Operating Company, Inc.
Antero Energy, LLC
Argonne National Laboratories
Astrella & Rice, PC
Ballard Petroleum Holdings, LLC
Biodiversity Associates
Bjork, Lindley, Danielson, & Little
BKS Environmental Associates, Inc
Bowers Oil and Gas
Cambria Oil
Carl Underwood Oil and Gas Company
Celsius Energy Corporation
Chaco Energy Company
CMS Oil & Gas
Coleman Oil and Gas, Inc.
Daly Law Associates
Daub and Associates

Daube Company
Double Eagle Petroleum & Mining Company
Emerald Operating Company
Farleigh Oil Properties
Fence Creek Ranch
GR Consulting
Hathaway Land Services
Independent Landman
Independent Production
J.M. Huber Corp
Jacobs Ranch Mine
Jim's Water Service
Kennecott Energy Company
Lance Oil & Gas Company, Inc.
Lonabaugh and Riggs
M&K Oil Company
Marathon Oil Company
Mercury Exploration Company
Michiwest Energy, Inc.
Minerals Diversified Services
Moncrief Oil
MTG Operating
Nielson & Associates
North Finn LLC
Oilfield Compliance
Osborn Heirs Company
Padlock Ranch Company
Peak Exploration
Petroleum Development Corp.
Petrox Resources, Inc.
Pioneer Oil & Gas
Powder River Oil
Prima Oil & Gas Co.
Quantum Energy
Remington Creek, LLC
Rio Algom Mining Corp.
Sands Oil Company
Stone Energy, LLC
T. Johnson Drilling

The Termo Company
WBI Holdings, Inc.
Williams Production RMT
Woodward-Clyde Consultants
Yates Petroleum

Educational Institutions

Campbell County Public Library
Johnson County Library
Natural Resources Library
Sheridan College
Univ. of WY Libraries/Collection Dept.
Wyoming, State Library

Individuals

Ingwersen, F.
Jeremiah, S.
Lorenzen, R.
Mengel, M.
Nichols, A.
Swanson, J.
Swartz, E.
Whitehead III, N.
Zimmer, R.

Chapter 9
Glossary

Chapter 9 — Glossary

Acid Neutralizing Capacity – The extent to which natural water bodies are able to buffer atmospheric deposition of sulfate and/or nitrate particulate matter from air pollution emission sources.

Acre-feet – The volume of liquid or solid required to cover one acre to a depth of one foot, or 43,560 cubic feet; measure for volumes of water, reservoir rock, etc.

Adsorb – A process by which molecules are taken up on the surface of a solid by chemical or physical action. Large amounts of gases, for example, may be adsorbed on the surface of a porous material such as charcoal.

Ad valorem – A tax on items that is imposed at a rate percent of value.

Affected Environment – The natural, physical, and human-related environment that is sensitive to changes due to proposed actions; the environment under the administration of a land management agency.

Air Dispersion Modeling – A complex computer model that calculates ambient concentrations of air pollutants.

Allotment – A unit of land suitable and available for livestock grazing that is managed as one grazing unit.

Alluvial – Deposited by a stream.

Alluvial Fan – A fan-shaped deposit of unsorted stream sand and gravel located where an ephemeral stream issues from a relatively steep mountain valley on to a relatively flat plain.

Alluvial Valley – A valley containing stream-deposited silt, sand, and gravel.

Alluvium – Unconsolidated or poorly consolidated gravel sands and clays, deposited by streams and rivers on riverbeds, floodplains, and alluvial fans.

Ambient – The environment as it exists at the point of measurement and against which changes or impacts are measured.

Ambient Concentration – The mass of a pollutant in a given volume of air. It is typically measured as micrograms of pollutant per cubic meter of air.

Ancillary Facility – Additional support structures required to develop the mineral resource. In the case of CBM development, this consists of gas compressor facilities, roads, collection pipelines, and electric power lines.

Animal Month – for cow/calf operations, it is the amount of forage consumed by a 1,000-pound cow and calf (less than 6 months of age) over a one-month period. It is approximately 1,050 pounds of forage.

Annulus – The space between the well casing and the boundary of the hole.

Antiquities – A general term for archaeological or paleontological resources that are at least 100 years of age and that tangibly represent or have the potential to yield information on historical or prehistoric cultures, or extinct plants and animals.

Aquifer – A body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs.

Assemblage – A group of rocks grouped together by age or similar origin.

Authorizing Officer – Person designated by an Agency as being in the position to speak for and commit the agency to action.

Avoidance Area – An environmentally sensitive area designated by an Agency. Authorizations would be granted only in cases where there is a prevailing need and no practical alternative exists, and then only with provisions to protect the sensitive resources.

Azimuth – Horizontal direction expressed as the angular distance between the direction of a fixed point and the direction of the object.

Background – The viewing area of a distance zone that lies beyond the foreground-middleground. Usually from a minimum of 3 to 5 miles to a maximum of about 15 miles from a travel route, use area, or other observer position. Atmospheric conditions in some areas may limit the maximum to about 8 miles or increase it beyond 15 miles.

Best Management Practices – a practice or combination of practices determined by the state to be the most effective and practicable (including technological, economic and institutional considerations) means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

Big Game – Large species of wildlife that are managed for hunting.

Biotic – Pertaining to life and living organisms.

Blow Out Prevention Equipment – A series of valves on the drill rig that can close down the well in the event that the drill bit penetrates extreme pressure zones.

Bond – Financial guarantee to ensure compliance with the Mineral Leasing Act, including complete and timely plugging of wells, reclamation of lands or

adversely affected surface waters, payment of royalties, assessments, or penalties.

Broadcast Seeding – Distribution of seed by a fan spreader or by hand spreading.

Canopy – The more-or-less continuous cover of branches and foliage formed collectively by the crown of adjacent trees and other woody growth.

Carbon Dioxide (CO_2) – A non-hydrocarbon, corrosive gas that occurs naturally in the gaseous phase in the natural gas reservoir, or is injected into the reservoir in connection with pressure maintenance, gas cycling, or other secondary or enhanced recovery projects.

Casing – (N) A steel pipe that maintains the opening of a drill hole. (V) The act of installing pipe within a well.

Catalyst – A substance that enables a chemical reaction to proceed at a usually faster rate or under different conditions than otherwise possible.

Cation – A positive ion, which in electrolysis, travels to the cathode and is discharged there.

Cement Bond Log – A geophysical log which confirms the continuous placement of cement within the annulus of the well, to isolate the formation of interest and to prevent commingling of different aquifers around the casing.

Characteristic Landscape – The established landscape within an area being viewed. The term does not necessarily mean a naturalistic character, but may refer to features of the cultural landscape, such as a farming community, an urban landscape, or other landscape that has an identifiable character.

Clean Air Act – Public Law 84–159, established July 14, 1955, and amended numerous times since. The Clean Air Act: establishes Federal standards for air pollutants emitted from stationary and mobile sources; authorizes states, tribes and local agencies to regulate polluting emissions; requires those agencies to improve air quality in areas of the country which do not meet Federal standards; and to prevent significant deterioration in areas where air quality is cleaner than those standards. The Act also requires that all Federal activities (either direct or authorized) comply with applicable local, state, tribal and Federal air quality laws, statutes, regulations, standards and implementation plans. In addition, before these activities can take place in non-attainment or maintenance areas, the Federal agencies must conduct a Conformity Analysis (and possible Determination) demonstrating the proposed activity will comply with all applicable air quality requirements.

Climatology – Science of climate and its causes.

Coal bed – A seam or stratum of coal parallel to the rock stratification.

CFR – Code of Federal Regulations, the compilation of federal regulations adopted by federal agencies through a rule-making process.

Colluvial – Consisting of a mixture of soil and angular fragments of rock that have accumulated at the foot and on slopes of mountainsides under the influence of gravity.

Colluvium – A mixture of soil and angular fragments of rock that have accumulated at the foot and on slopes of mountainsides under the influence of gravity.

Community (plant community) – An assembly of plants living together, reflecting no particular ecological status.

Community Types (vegetation) – A group of plants living in a specific region under relatively similar conditions.

Compressor – Equipment (electrically or gas-driven) used to increase the pressure on the produced gas to move it into transmission lines or into storage.

Conglomerate – A sedimentary rock comprised of an unstratified mixture or stratified layers of cobbles, gravel, and sand.

Coniferous – Referring to a cone-bearing, usually evergreen, tree.

Contrast – The effect of a striking difference in the form, line, color, or texture of the landscape features within the area being viewed.

Criteria Pollutants – Air pollutants for which the EPA has established State and National Ambient Air Quality Standards. These include particulate matter (PM_{10}), nitrogen oxides (NOx), sulfur dioxide (SO_2), carbon monoxide (CO), and volatile organic compounds (VOC).

Cubic Foot – The volume of gas contained in one cubic foot of space at a standard pressure base of 14.7 psia and a standard temperature base of 60 degrees Fahrenheit.

Cultural Resources – The archaeological and historical remains of human occupation or use. Includes any manufactured objects, such as tools or buildings. May also include objects, sites, or geological/geographical locations significant to Native Americans.

Cultural Significance – Is embodied in those qualities of prehistoric or historic districts, sites, buildings, structures, or objects that meet the National Register Criteria for Evaluation (36CFR60.4). The application of these criteria is explained in the National Register Bulletin 15, distributed by the National Park Service.

Cumulative Effects – As defined by 40 CFR 1508.7, cumulative effects are the impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future

actions, regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.

dBA – The sound pressure levels in decibels measured with a frequency weighing network corresponding to the A-scale on a standard sound level meter. The A-scale tends to suppress lower frequencies, e.g., below 1,000 Hz.

Decibels (dBA) – Units for describing amplitude of sound frequencies to which the human ear is sensitive.

Deciduous – Trees or shrubs that lose their leaves each year during a cold or dry season.

Decommissioning – Generally, the removal of a facility or piece of equipment from service, or a change in status from active to inactive.

Demographic – Pertaining to the study of human population characteristics including size, growth rates, density, distribution, migration, birth rates, and mortality rates.

Desorb – To restore an adsorbed substance.

Direct Effects – As defined by 40 CFR 1508.9, these are effects that are caused by the action and occur at the same time and place as the action. Synonymous with direct impacts.

Direct Impact Area – An area analyzed for the effects of an action that would occur at the same place in time.

Discharge – The volume of water flowing past a point per unit time, commonly expressed as cubic feet per second (cfs), gallons per minute (gpm), or million gallons per day (mgd).

Dispersed Recreation – A general term referring to recreation use outside the developed recreation sites. This includes activities such as scenic driving, hunting, hiking, OHV use, and biking.

Distance Zones – Areas of landscapes denoted by specified distances from the observer. Used as a frame of reference in which to discuss landscape characteristics or activities of man.

- Background (bg) – Area located from 3–5 miles to infinity from viewer.
- Middleground (mg) – Area located from 0.25–0.50 to 3–5 miles from the viewer.
- Foreground (fg) – The detailed landscape found within 0 to 0.25–0.50 mile from the viewer.

Disturbance – An event that changes the local environment by removing organisms or opening up an area, facilitating colonization by new, often different, organisms.

Disturbed Area – Area where natural vegetation and soils have been removed or disrupted.

Diversity – The distribution and abundance of different plant and animal communities and species within the area covered by a Land and Resource Management Plan.

Drainage – Natural channel through which water flows some time of the year. Natural and artificial means for effecting discharge of water as by a system of surface and subsurface passages.

Drill Bit – The cutting devise used to drill a well. It is typically made of hardened steel, and may have industrial grade diamond components.

Drilling Mud – The circulating fluid used to bring cuttings out of the well bore, cool the drill bit, and provide hole stability and pressure control. Drilling mud includes a number of additives to maintain the mud at desired viscosities and weights. Some additives that may be used are caustic, toxic, or acidic.

Earthquake – Sudden movement of the earth's crust resulting from faulting, volcanism, or other mechanisms.

Ecosystem – An interacting system of organisms considered together with their environment for example, marsh, watershed, and stream ecosystems.

Ecotone – The boundary or transition zone between adjacent plant communities, often delineating different habitat types.

Effects – Environmental consequences as a result of a proposed or alternative action. Included are direct effects, which are caused by the action and occur at the same time and place, and indirect effects, which are caused by the action and are later in time or further removed in distance but which are still reasonably foreseeable. Also referred to as impacts.

Endangered Species – Any species of animal or plant which is in danger of extinction throughout all or significant portions of its range and has been designated "endangered" in the Federal Register by the Secretary of the Interior. Disturbance of the habitat of endangered species is prohibited by the Endangered Species Act of 1973, as amended.

Endemic – Confined naturally to a particular geographic area. Often used in opposition to the word epidemic.

Environment – The aggregate of physical, biological, economic, and social factors affecting organisms in an area.

Environmental Analysis – An analysis of alternative actions and their predictable environmental effects, including physical, biological, economic, and social consequences and their interactions; short- and long-term effects; direct, indirect, and cumulative effects.

Environmental Assessment – A concise public document which serves to (a) Briefly provide sufficient evidence and analysis for determining whether to prepare an EIS or a Finding of No Significant Impact; (b) Aid an agency's compliance with NEPA when no EIS is necessary; (c) Facilitate preparation of an EIS when necessary.

Environmental Impact Statement – An analysis of alternative actions and their predictable environmental effects, including physical, biological, economic, and social consequences and their interactions; short- and long-term effects; direct, indirect, and cumulative effects.

Environmental Justice – Executive Order 12898 (February 11, 1994) mandates Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

Ephemeral Drainage – A drainage area or a stream that has no base flow. Water flows for a short time each year but only in direct response to rainfall or snowmelt events.

Emission – Air pollution discharge into the atmosphere, usually specified by mass per unit time.

Erosion – Detachment or movement of soil or rock fragments by water, wind, ice, or gravity. Accelerated erosion is much more rapid than normal, natural or geologic erosion, primarily as a result of the influence of activities of man, animals, or natural catastrophes.

Exploration – The search for economic deposits of minerals, ore, and other materials through practices of geology, geochemistry, geophysics, drilling, and/or mapping.

Fault – A fracture in bedrock along which there has been vertical and/or horizontal movement caused by differential forces in the earth's crust.

Faulting – Relative displacement of adjacent bedrock along a fracture.

Fisheries – Streams and lakes used for fishing.

Fisheries Habitat – streams, lakes, and reservoirs that support fish.

Flaring – The controlled ignition of natural gas at a wellhead.

Floodplain – That portion of a river valley, adjacent to the channel, which is built of recently deposited sediments and is covered with water when the river overflows its banks at flood stages.

Fluvial – Comprehensive term for river processes.

Footprint – The actual surface area physically disturbed by oil and gas operations and ancillary facilities.

Forage – Vegetation used for food by wildlife, particularly big game wildlife and domestic livestock.

Forb – A broad-leaved flowering plant.

Foreground-Middleground – The area visible from a travel route, use area, or other observer position to a distance of 3 to 5 miles. The outer boundary of this zone is defined as the point where the texture and form of individual plants are no longer apparent in the landscape, and vegetation is apparent only in pattern or outline.

Fracturing – A method of stimulating well production by increasing the permeability of the producing formation. Fracture fluids, which include propping agents such as, sand or glass beads, are pumped into the formations under extremely high hydraulic pressure. The propping agents facilitate the formation of channels to release water and gas into well.

Fugitive Dust – Airborne particles emitted from any source other than through a controllable stack or vent.

Game Species – Animals commonly hunted for food or sport.

Gas Venting – The release of gas into the atmosphere following well development and before successful installation of the collection pipeline system.

Geotechnical – A branch of engineering concerned with the engineering design aspects of slope stability, settlement, earth pressures, bearing capacity, seepage control, and erosion.

Glacial Outwash – The material deposited by streams flowing within a glacier and by melt-waters during times of glacial advance and retreat.

Grade – A slope stated in terms of feet per mile or as feet per feet (percent); the content of precious metals per volume of rock (ounces per ton).

Groundwater – All subsurface water, especially that as distinct from surface water portion in the zone of saturation.

Habitat – The place or type of site where a plant or animal naturally or normally lives and grows. Includes all biotic, climatic, and soils conditions, or other environmental influences affecting living conditions.

Habitat Diversity – the distribution and abundance of different plant and animal communities and species within a specific area.

Habitat Fragmentation – The process by which habitats are increasingly subdivided into smaller units, resulting in their increased isolation as well as loss of total habitat area.

Habitat Type – The aggregate of all areas that support or can support the same primary vegetation at climax.

Herbaceous – The plant strata which contain soft, not woody, stemmed plants that die to the ground in winter.

Historic Landscape – A type of historic district that is a geographic area, or the sites, buildings, structures, natural and cultural features, and objects within a defined geographic area, that together, represents a defined historic or prehistoric theme and period. The definition of a historic landscape includes: (1) a significant theme (linkage or continuity) such as a particular economic activity or ethnic group, (2) definitions of those sites, buildings, structures, natural features, cultural landscape modifications, and objects (property types) which represent the theme, and (3) a cultural period or date range.

Hydrogen Sulfide (H_2S) – A flammable, poisonous, corrosive gas with an odor suggestive of rotten eggs, which can occur naturally in the gaseous phase in natural gas reservoirs.

Hydrology – A science that deals with the properties, distribution, and circulation of surface and subsurface water.

Hydrostatic Testing – Testing of the integrity of a newly placed, but uncovered pipeline for leaks. The pipeline is filled with water and pressurized to operating pressures, and the pipeline is visually inspected.

Impoundment – The accumulation of any form of water in a reservoir or other storage area.

Indemnify – To secure against, or to provide compensation for incurred loss, hurt, or damage.

Indirect Effects – As defined by 40 CFR 1508.8, these are effects which are caused by the action but occur later in time or are removed in distance from the action, but are still reasonably foreseeable. Synonymous with indirect impacts.

Infiltration – The movement of water or some other liquid into the soil or rock through pores or other openings.

Infrastructure – The basic framework or underlying foundation of a community including road networks, electric and gas distribution, water and sanitation services, and facilities.

Injection Well – Any well used for the disposal or air, gas, water or other substance into any underground stratum.

Intermittent Stream – A stream that flows only at certain times of the year when it receives water from alluvial ground water, springs, or from some surface source such as melting snow in mountainous areas.

Irretrievable – Applies to the loss of production, harvest, or use of natural resources. For example, some or all of the timber production from an area is lost irretrievably while an area is serving as a winter sports site. The produc-

tion lost is irretrievable, but the action is not irreversible. If the use changes, it is possible to resume timber production.

Irreversible – Applies primarily to the use of nonrenewable resources, such as minerals or cultural resources, or to those factors that are renewable only over long time spans, such as soil productivity and aspen regeneration. Irreversible also includes loss of future options.

Landform – Any physical, recognizable form or feature of the Earth's surface, having a characteristic shape and produced by natural causes. Includes major features such as plains, plateaus, and mountains, and minor features, such as hills, valleys, slopes, canyons, arroyos, and alluvial fans.

Landscape Character – The arrangement of a particular landscape as formed by the variety and intensity of the landscape features as defined as the four basic elements (form, line, color, and texture). These factors give the area a distinctive quality that distinguishes it from its immediate surroundings.

Landslide – A perceptible downhill sliding or falling of a mass of soil and rock lubricated by moisture or snow.

Land Use – Land uses determined for a given area that establish the types of activities allowed (e.g., mining, agriculture, timber production, residential, industrial).

Lease – Any contract, profit-share arrangement, joint venture or other agreement issued or approved by the United States under a mineral leasing law that authorizes exploration for, extraction of or removal of oil or gas.

Lek – An area used by sage grouse for mating displays (strutting ground).

Lithic Scatter – Is a surface scatter of cultural artifacts and debris that consists entirely of lithic (i.e., stone) tools and chipped stone debris. This is a common prehistoric site type that is contrasted to a cultural material scatter, which contains other or additional artifact types such as pottery or bone artifacts, to a camp which contains habitation features, such as hearths, storage features or occupation features, or to other site types that contain different artifacts or features.

Loam – A mixture of sand, silt, and clay containing between 7 and 27 percent clay, 28 to 50 percent silt, and less than 50 percent sand.

Locus – Is a discrete place or physical location generally used in describing the qualities of a site. When the term is used in contrast to a site, it refers to a locality containing the traces of a brief, limited or transient cultural activity.

Long-Term Impacts – For the purpose of the Powder River Oil and Gas NEPA analysis, long-term effects generally last beyond the construction period.

Macroinvertebrates – Aquatic invertebrate animals that live on or in the surface of the substrate of streams or lakes.

Management Area – an area composed of aggregate pieces of land (generally several to many analysis areas) to which a given management objective and prescriptions are applied.

Management Direction – a statement of multiple use and other goals and objectives, along with the associated management prescriptions and standards and guidelines to direct resource management.

Median – A value in an ordered set of values above and below which there are an equal number of other values.

Mesic – A habitat characterized by moderate moisture and temperature conditions and by a profusion of plant life.

Methane (CH_4) – The simplest hydrocarbon; natural gas is nearly pure methane.

Mitigate – To lessen the severity.

Mitigation – Actions to avoid, minimize, reduce, eliminate, or rectify the impact of a management practice.

Modified Mercalli Intensity Scale – A qualitative measurement scale describing the intensity (degree of shaking) felt by people, structures, and the ground. Intensities range from I (felt by few, if any, people) to XII (damage total).

Monitor – To systematically and repeatedly watch, observe, or measure environmental conditions in order to track changes.

Monoculture – An area characterized by the vegetation consisting of a single species, e.g. a wheat field.

Mottled – Marked by different shaded spots.

National Ambient Air Quality Standards (NAAQS) – The allowable concentrations of air pollutants in the air specified by the Federal government. The air quality standards are divided into primary standards (based on the air quality criteria and allowing an adequate margin of safety and requisite to protect the public health) and secondary standards (based on the air quality criteria and allowing an adequate margin of safety and requisite to protect the public welfare from any unknown or expected adverse effects of air pollutants).

National Register of Historic Places – A list, maintained by the National Park Service, of areas which have been designated as being of historical significance.

Native Species – Plants that originated in the area in which they are found, i.e., they naturally occur in that area.

Natural Gas – Those hydrocarbons, other than oil and other than natural gas liquids separated from natural gas, that occur naturally in the gaseous phase in

the reservoir and are produced and recovered at the wellhead in gaseous from. Natural gas includes coal bed methane gas.

National Environmental Policy Act – The National Environmental Policy Act of 1969. It is the national charter for protection of the environment. NEPA establishes policy, sets goals, and provides means for carrying out the policy. Regulations at 40 CFR 1500–1508 implement the act.

Nesting Substrate – The site on which a nest is placed such as a tree, cliff, or ground.

Noxious Weeds – An alien, introduced, or exotic undesirable species that is aggressive and overly competitive with more desirable native species.

Ozone – A molecule containing three oxygen atoms (O_3) produced by passage of an electrical spark through air or oxygen (O_2).

Pan Evaporation – a measurement of water loss to the atmosphere from a standard evaporation pan with a diameter of 47.5 inches and a depth of 10 inches.

Paleontology – The science that deals with the history and evolution of life on earth.

Particulate Matter – A particle of soil or liquid matter (e.g., soot, dust, aerosols, fumes and mist).

Passerine – A taxonomic order that includes perching birds and songbirds.

Peak Flow – The greatest flow attained during melting of winter snowpack or during a large precipitation event.

Perennial – A plant whose life cycle lasts longer than two years. The tops of herbaceous perennials die down at the end of the growing season, buds, roots, and underground portions persist.

Perennial Stream – A stream or reach of a stream that flows throughout the year.

Permeability – The capacity of a soil or groundwater aquifer to transmit water.

Permeable – The property or capacity of a porous rock, sediment, or soil to transmit a liquid.

pH – The negative $\log_{10}$ of the hydrogen ion activity in solution; a measure of acidity or basicity of a solution.

Physiographic – Pertaining to the genesis and evolution of landforms.

PM_{10} – Airborne suspended particles with an aerodynamic diameter of 10 microns or less.

Porosity – The voids or openings in geological materials.

Potentiometric surface – A surface that represents the total head in an aquifer; it represents the height at which the water level stands in tightly cased wells that penetrate the aquifer.

Prevention of Significant Deterioration (PSD) – A regulatory program under the Clean Air Act (Public Law 84-159, as amended) to limit air quality degradation in areas currently achieving the National Ambient Air Quality Standards. The PSD program established air quality classes in which differing amounts of additional air pollution is allowed above a legally defined baseline level. Almost any additional air pollution would be considered significant in PSD Class I areas (certain large national parks and wilderness areas in existence on August 7, 1977, and specific Tribal lands redesignated since then.) PSD Class II areas allow that deterioration associated with moderate, well-controlled growth (most of the country). Although Class III areas would allow greater incremental impacts planned individual growth, no Class III areas have been established.

Produced Water – Formation water pumped during the development of a gas well.

Productivity – In reference to vegetation, productivity is the measure of live and dead accumulated plant materials.

Range – Land producing native forage for animal consumption and lands that are revegetated naturally or artificially to provide forage cover that is managed like native vegetation, which are amenable to certain range management principles or practices.

Raptor – A bird of prey with sharp talons and strongly curved beaks, which preys on living animals (e.g., eagles, hawks, falcons, and owls).

Recharge – Replenishment of the water supply in an aquifer through the outcrop or along fracture lines.

Reclamation – The process of restoring disturbed areas using any of several methods, recontouring, spreading topsoil or growth medium, seeding, and planting, among others.

Recontouring – Restoration of the natural topographic contours by reclamation measures, particularly in reference to roads.

Record of Decision – A decision document for an Environmental Impact Statement or Supplemental EIS that publicly and officially discloses the responsible official's decision regarding the actions proposed in the Environmental Impact Statement and their implementation.

Recreation Opportunity Spectrum Settings – A system of measuring the land's ability to meet the expectations of recreation users. Six recreation categories, from primitive (natural) to urban (highly modified) describe the

activities, settings, and experiences an area offers. The following categories may be found in or near the analysis area:

- Urban – a highly modified environment, although the background may have natural elements. Sights and sounds of man predominate, and large numbers of users can be expected.
- Rural – an area characterized by the sights and sounds of rural residential and agricultural land uses. The interaction between users is often moderate to high.
- Roaded Natural – a road corridor with a landscape that is characterized as natural or natural appearing. The road has moderate to high use.
- Semi-Primitive Motorized – a natural area predominantly unmodified by man. There are opportunities for isolation from the sights and sounds of man, but occasional evidence of other area users.

Recreation Visitor Day – A measurement equivalent to one person recreating for 12 hours or several people for a total of 12 hours.

Reserve Pit – A pit prepared on a well pad before drilling to use for wastewater retention, evaporation, and disposal. Wastewaters will have a fine solids component.

Reserves – Identified resources of mineral-bearing rock from which the mineral can be extracted profitably with existing technology and under present economic conditions.

Residuum – Unconsolidated material that accumulates by weathering of parent material in place.

Resources (geologic) – Reserves plus all other mineral deposits that may eventually become available – either known deposits that are not recoverable at present, or unknown deposits, that may be inferred to exist but have not yet been discovered.

Riffle – A shallow section of stream with rapid current and a surface broken by gravel, rubble, or boulders.

Rights-of-Way – An accurately located strip of land with defined width, point of beginning, and point of ending. It is the area within which the user has authority to conduct operations approved or granted by the landowner in an authorizing document, such as a permit, easement, lease, license, or Memorandum of Understanding.

Riparian – Land areas that are directly influenced by water. They usually have visible vegetative or physical characteristics showing this water influence. Streamsides, lake borders, or marshes are typical riparian areas.

Riparian Ecosystem – a transition between the aquatic ecosystem and adjacent upland terrestrial ecosystem; identified by soil characteristics and distinctive vegetation communities that require free or unbounded water.

Rockfall – Rapid fall of a detached piece of bedrock from a cliff or steep slope.

Roosting – To rest or sleep in a roost. A bird will typically use the same roost over an extended period of time.

Runoff – That part of precipitation that appears in surface streams. Precipitation that is not retained on the site where it falls and is not absorbed by the soil.

Salmonidae – A family of fish that includes salmon and trout.

Salmonid Spawning Areas – Waters that provide or could provide a habitat for active self-propagating populations of salmonid fishes.

Scatter (archeological) – Random evidence of prior disturbance that is distributed about an area rather than concentrated in a single location.

Scoping – Procedures by which agencies determine the extent of analysis necessary for a proposed action, (i.e., the range of actions, alternatives, and impacts to be addressed; identification of significant issues related to a proposed action; and the depth of environmental analysis, data, and task assignments needed).

Sedge – Plants that resemble grasses but have hollow rather than woody stems.

Sediment – Soil or rock particles that have been transported to stream channels or other bodies of water. Sediment input comes from natural sources, such as soil erosion, rock weathering, agricultural practices, or construction activities.

Sediment Load – The amount of sediment (sand, silt, and fine particles) carried by a stream or river.

Sedimentary – Rock formed from fragments of pre-existing rocks (e.g. sandstone) or by precipitation from solution (e.g. limestone).

Seedling – Newly germinated plants.

Seismic – Pertaining to or produced by earthquakes.

Sensitive Species – Those species of plants or animals that have appeared in the Federal Register as proposed for classification and are under consideration for official listing as endangered or threatened species under the Endangered Species Act. This also includes species that are on an official state list or are recognized by the Land Manager as needing special management to prevent their being placed on federal or state lists.

Sensitivity Level – a particular degree or measure of viewer interest in the scenic qualities of the landscape.

- Sensitivity Level 1 – The highest sensitivity level, referring to areas seen from travel routes and use areas with moderate to high use.

- Sensitivity Level 2 – An average sensitivity level, referring to areas seen from travel routes and use areas with low to moderate use.
- Sensitivity Level 3 – The lowest sensitivity level, referring to areas seen from travel routes and use with low use.

Short-Term Impacts – For the purpose of the Powder River Basin Oil and Gas NEPA analysis, short-term impacts are generally defined as those that would occur during the construction period.

Shut In – Refers to a well that is completed, is shown to be capable of production in paying quantities, and is not presently being operated.

Significant – As used in NEPA determination of significance requires consideration of both context and intensity. Context means that the significance of an action must be analyzed in several contexts such as society as a whole, and the affected region, interests, and locality. Intensity refers to the severity of impacts (40 CFR 1508.27).

Slump – Slide or earthflow of a soil mass.

Soil – Loose, unconsolidated surface material comprising topsoil and subsoil.

Spawning – The deposition of eggs and sperm by fish.

Species – Organisms that successfully reproduce among themselves and cannot reproduce successfully with other organisms.

Species of Special Concern – A native species whose population is low and limited in distribution or has suffered significant reductions because of habitat loss.

Specific Conductance (umhos/cm) – A measure of electrical conductivity in water that is influenced by the mineral content of the water.

Stormwater Runoff – Overland runoff from snowmelt or a precipitation event.

Strata – An identifiable layer of bedrock or sediment; does not imply a particular thickness of rock.

Substrate – Material consisting of silts, sands, gravels, boulder and woody debris found on the bottom of a stream channel.

Target formation – The geological association of rocks that contain the exploitable mineral reserves.

Telemetry – Instrumentation to transmit scientific equipment readings from remote locations to a central site.

Threatened Species – Any species of animal or plant which is likely to become endangered within the foreseeable future throughout all or significant portions of its range. It has been designated in the Federal Register by the Sec-

retary of the Interior as a threatened species. Disturbance of the habitat of threatened species is prohibited by the Endangered Species Act of 1973, as amended.

Thrust Faulting – Low angle fracturing of bedrock in response to horizontal stress within the earth's crust

Total Dissolved Solids – Total amount of dissolved material, organic or inorganic, contained in a sample of water.

Total Suspended Soils – Amount of undissolved particles suspended in liquid.

Transmissivity – The rate at which water is transmitted through a unit width of a groundwater aquifer or confining bed under a unit hydraulic gradient.

Turbidity – A fisheries measurement of the total suspended solids in water expressed as nephelometric turbidity units (NTU).

Understory – The trees and other woody species growing under a more-or-less continuous cover of branches and foliage formed collectively by the upper portion of adjacent trees and other woody growth.

Variety Class – a particular level of visual variety or diversity of landscape character. There are three variety classes; A, B, and C.

- Variety Class A – distinctive
- Variety Class B – common
- Variety Class C – minimal

Vegetation – All of the plants growing in and characterizing a specific area or region; the combination of different plant communities found there.

Visual Resource – The composite of basic terrain, geologic features, water features, vegetation patterns, and land use effects that typify a land unit and influence the visual appeal the unit may have for viewers.

Visual Resource Management System – The BLM system for evaluating and classifying visual resources. The system uses line, form, color, texture, scale and space to categorize lands into one of four classes:

- Class I. Preservation
- Class II. Retention
- Class III. Partial Retention
- Class IV. Modification

Water Quality – refers to a set of chemical, physical, or biological characteristics that describe the condition of a river, stream, or lake. The quality of water determines which beneficial uses it can support. Different instream conditions or levels of water quality are needed to support different beneficial uses.

Waters of the United States – A jurisdictional term from Section 404 of the Clean Water Act referring to water bodies such as lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which could affect interstate or foreign commerce.

Watershed – All of the land that drains surface water to a given stream above a designated point (usually its mouth); also called a stream drainage or drainage basin.

Well Head – The equipment used to maintain surface control of a well. It is composed of the casing head, tubing head and a series of valves and fittings.

Well Pad – A level area constructed for the purpose of drilling a well.

Wetlands – Areas that are inundated by surface or groundwater with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetation or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.

Winter Range – The place where migratory (and sometimes non-migratory) animals congregate during the winter season.

Workover – Well maintenance activities that require onsite mobilization of a drill rig to repair the well bore equipment (casing, tubing, rods, or pumps) or the wellhead. In some cases, a workover may involve development activities to improve production from the target formation.

Chapter 10
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